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Nursery & Market Garden Industries' - - Development Society, Limited. - -

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Diagram showing arrangement of Experimental Plots in 1933.

Introduction.

THE year 1933 has been particularly interesting from the experimental view point, for it has been possible to study the reaction of glasshouse plants to long periods of unusually hot sunny weather. Much new information has been obtained, which has to a large extent confirmed the results of previous investigations.

The work of the Experimental and Research Station has made steady progress ; the number of inquiries received is increasing rapidly and many new members have been enrolled.

It is a pleasure to record that growers are taking greater advantage of the facilities for advice offered by the Station. To prevent any disappointment, in future, it is desirable that those who wish the Extension Officer to visit their nurseries should make application in good time.

In addition to inquiries from home growers, information is being sought by those who cultivate tomatoes and cucumbers in the Colonies.

Membership of the Society, under whose auspices the experiments are conducted, is open to all growers and interested persons. Subscriptions are payable at the rate of two guineas for each acre of glass cultivated by the subscriber ; in return members receive future publications and any advice which is available. Members continue to be enrolled, but many more are needed, both to provide additional funds for research and to obtain complete co-operation in controlling the various pests and diseases common to glasshouse plants. Serious outbreaks over a wide area must be fought by all growers ; isolated attempts to control disease are almost bound to fail.

Endowment Fund.

An endowment fund has been opened to receive contributions from those who desire to further the work of the Station. The amount collected is now £405. The capital is invested in Trustees and the interest only will be used for (a) future development, and (b) repayment of debt.

It is hoped that those who can possibly contribute to this fund will do so, and so help to secure the Station's future financial prosperity.

Winter Discussions.

The evening lectures for nursery owners and employees, commenced in 1925 at the request of the workers, were continued, the subjects selected being as follows :—

1932.

Oct. 5th.—The Tomato Crop in Guernsey.
A. Wheadon.

Nov. 7th.—The Cultivation of the Tomato.
W. F. Bewley, D.Sc.

Nov. 21st.—Pests of Glasshouse Plants.
E. R. Speyer, M.A.

Dec. 5th.—Diseases of Glasshouse Plants.
P. H. Williams, B.Sc., and
G. C. Ainsworth, B.Sc.

Dec. 19th.—Market Gardening in France.
W. F. Bewley, D.Sc.

1933.

Jan. 9th.—(a) Artificial Ripening of Tomato Fruits.
W. H. Read, M.Sc.

(b) Practical Extension Work in 1932.
O. B. Orchard.

Jan. 23rd.—Artificial Farmyard Manure.
E. Hanneford Richards, B.Sc., F.I.C.

Feb. 6th.—The Cultivation of the Cucumber.
W. F. Bewley, D.Sc.

Feb. 20th.—Open Night.

Our greatful thanks are due to the Lea Valley Growers' Association who so kindly provided a grant to cover the cost of hiring the lecture room and supplying light refreshments each evening.

Current Investigations.

Manurial and crop management trials with tomatoes have been continued. From the experiments with nitrogenous fertilisers, which have been four years in progress, it is clear that when these are applied as top dressings continually, throughout the season, the effects of sulphate of ammonia, nitrate of soda and nitrate of lime are similar. During normal weather, Peruvian Guano, dried blood and fish meal also give similar results, but seem slightly more effective than those mentioned above. During years of abundant sunshine, when adequate supplies of nitrogen are particularly necessary, dried blood and fish meal were most beneficial. As a base fertiliser, hoof and horn gave better results in the first year than cyanamide, and better results than shoddy for the first three years, but the cumulative effect of applying shoddy each year was seen in the fourth year when the yield from the shoddy plot exceeded slightly that from the hoof and horn plot. Applications of cyanamide to the soil three months before planting has given good results, especially during the second and fourth years ; the effect of this compound must be investigated further.

The experiment of planting tomatoes in trenches, which were filled in as soon as the lowest trusses had been picked, has not given the results which were expected. Soil conditions at the bottom of a six inch trench do not encourage root production as well as those near the surface and root injury has resulted each year. On lighter and warmer soils the method may be advantageous but it is not suitable for heavy compact soils.

Experiments on the improvement of physical conditions by the incorporation of straw, peat, spent hops and chrysanthemum roots have been continued. The use of

clean wheat or oat straw, placed vertically in the soil to a depth of twenty inches, can be recommended to growers as a means of improving heavy and medium soils.

Peat is also useful, but heavy dressings are required and the cost is probably too high for commercial work unless a source of good material exists near to the nursery. The results of adding spent hops are variable. The first year's crop usually shows an appreciable increase but the effect does not seem to be lasting, and some reduction in yield has been observed in the second year.

Chrysanthemum roots have given good results when healthy material is used, but the tomato crop has been adversely affected after using diseased roots. As particular care must be given to the selection of the material which can be employed with safety the use of chrysanthemum roots for increasing the organic matter in the soil cannot be recommended as a general practice.

The liming experiment, which has been in progress during the past six years, indicates clearly that the tomato can tolerate a certain degree of soil acidity. The value of liming has been overestimated in the past ; while light dressings constitute a safety measure, heavy dressings can be recommended only for the purpose of improving the physical condition of heavy clay soils.

The variety trials proved particularly interesting this year, because they shewed why the Kondine Red, Best of All types are so popular in the warmer sunny areas of the country. This variety thrived under the exceptional summer conditions, and produced crops which were abnormally heavy for these varieties in the Lea Valley district.

The highest yields, however, came from the Guernsey strain of Radio, and another Guernsey type, Radio × Kondine Red. The varieties resistant to leaf mould retained their resistance and are producing heavier crops of good quality fruit as the result of continued selection. The best type was Stirling Castle × E.S.1., while Up-to-date × Tuckswood promises to be good after further selection.

The soil heating experiments with tomatoes were extended, and it has been possible to make definite recommendations for heating the soil of commercial nurseries by means of a system of buried hot water pipes. A crop increase of some 30% was obtained on a fairly large scale as the result of raising the soil temperature from 65°F. to 80°F.

Similar investigations with cucumber beds are in progress, and indicate as before that healthier plants and heavier crops can be produced by warming the soil artificially.

The oil fuel experiment was continued and while excellent temperature control was obtained the cost of fuel has proved to be higher than when anthracite is used.

Experiments were begun with the Iron Fireman type of automatic stoker, which uses a cheap form of soft coal. This is driven electrically and is thermostatically controlled. Preliminary results are promising.

Work with the new winter forcing lettuce "Cheshunt Early Giant" is being continued. An excellent crop of well-hearted lettuce was marketed during the last fortnight in February from plants set out in the houses during the first week of the previous December. Also a crop of well-hearted heads was marketed at Christmas from plants planted on October 5th, following removal of the tomato plants. This variety is a great improvement on existing types, for it reaches maturity some three weeks earlier, and develops solid hearts during short days. It is hoped that seeds will be available to growers in time for the next winter crop.

Satisfactory results in the control of the tomato-moth caterpillar have been obtained on an experimental scale by spraying plants with a mixture of synthetic Cryolite (aluminium sodium fluoride) and Rape Oil, as a substitute for lead arsenate. A tomato house into which many caterpillars had been introduced, and which was sprayed once every six weeks during the growing season, was free of the pest in August and September. A good crop was obtained from the plants, and deposit upon the fruit due to spraying

was easily removed by wiping. For spraying purposes the admixture of an oil is necessary to bring about adhesion of the Cryolite to the foliage, and only certain types of Cryolite can be mixed with an oil. These have been difficult to obtain, but recently a colloidal Cryolite has been manufactured which may prove of value, especially for use on nurseries where lettuce is grown in the spring between the rows of tomatoes.

In July, 1933, a Chalcid parasite *(Comedo spaculus* Thoms.) of the Tomato-moth caterpillar made its appearance at the Experimental Station. A close study has been made of its remarkable habits and life-history, and a stock of chrysalids is being kept over the winter. In addition it has been possible to breed the parasite in small numbers during the winter months on caterpillars of the Angle-Shades Moth. It is doubtful, however, if this parasite will have any appreciable effect in the control of the tomato moth upon commercial nurseries.

An investigation into the habits of the Ichneumon parasite *(Pimpla instigator* L.*)* is being undertaken with a view to increasing the numbers of this useful insect in tomato houses.

Certain spray fluids purporting to contain Rotenone have been tested upon the Red Spider Mite on the tomato plant. Solutions of Rotenone in acetone have been similarly tried. The results have been unsatisfactory. As some 70% of the mite upon the foliage are in the egg stage during the greater part of the growing season, no spray or fumigant which is without ovicidal action, or the killing properties of which do not last for a number of days upon the foliage, can be of much value in controlling this pest.

Since 1924, the grubs of one of the Cecidomyid flies *(Therodiplosis persicæ* Kieff*)*, which feed upon the Red Spider Mite, have annually become more prevalent in tomato houses in the Lea Valley. They have also been observed upon strawberry plants and peach trees grown under glass, but do not occur in cucumber houses. Attempts are being made to discover how the insect passes the winter.

The Onion Thrips (*Thrips tabaci*, Lind.) as a vector of Spotted Wilt disease, must now be regarded as an important pest of the Tomato plant. Although the insect breeds mostly upon the Cucumber plant and in the flowers of Carnation, Cyclamen, and Arum, it frequently attacks the tomato, and can carry infection from a former host even after a period of hibernation in the soil. Control measures consist in steaming the soil in winter, and eradicating weeds, especially Yarrow, from the vicinity of glasshouses, near which it is undesirable also to grow potatoes or onions.

The millepede *Blanjulus guttulatus* often occurs in undesirable numbers in the soil of tomato houses, though damage to the roots by it has not been proved. The amount of naphthalene to be dug into the soil during the autumn in order to kill these millepedes is found to be at least 8 ounces per square yard, i.e. about four times the amount usually applied upon commercial nurseries. Many other compounds have been tested in commercial cucumber houses, but it was found that the method of spreading naphthalene over the borders gave the most satisfactory control.

The breeding and distribution of the White Fly parasite *Encarsia formosa*, Gehan, has been continued. This parasite is in considerable demand. Experiments directed to discover a satisfactory control of wireworms in glasshouse soils have been continued without success.

The investigation of "Leafy Gall" of the chrysanthemum has been continued, paying particular attention to the question of control. When cuttings were taken from apparently clean plants the extent of the infection in the mature plants was about 30%, but with cuttings from infected plants the infection rate was between 50% and 80% in the different batches. A reduction in percentage infection was also obtained by adding a little calcium sulphate to the compost in which the cuttings were inserted, but this compound was not effective when treatment was delayed until the rooted cuttings were potted into three inch pots. The organism described in the previous report has been isolated again this year, and inoculation experiments were again inconclusive.

The investigation of Rose diseases, mainly rust, powdery mildew and die-back has been continued. Experiments have shewn that a satisfactory control of rose mildew may be achieved by spraying with an oil and copper compound.

Various factors in connection with the physical and chemical nature of soils have been studied in relation to the incidence and severity of virus diseases of the tomato. Samples of soil were obtained from nurseries where mosaic diseases are both prevalent and serious. It was found that when tomato plants grown in these soils and also in water logged soils. were inoculated with aucuba mosaic, the disease was more pronounced than in a similar series of inoculated plants grown in a standard compost. No evidence was obtained that such soil conditions are solely responsible for the presence of virus diseases.

In addition it was found that the presence of plant poisons in the soil increased the severity of the disease in tomato plants inoculated with aucuba mosaic, but numerous tests in soil and water culture experiments failed to produce symptoms of virus diseases in uninoculated plants.

The study of Spotted Wilt was continued. This disease was recorded from thirteen English counties, from Wales and from Ireland during the season, and was the subject of a special circular.

The mosaic diseases of the cucumber have been examined and two types described. One type can only infect the cucumber and allied plants while the other has a much wider host range and causes true fern leaf of tomato.

An attempt has been made by means of manurial experiments in pots to demonstrate the effect of different treatments upon the severity of aucuba mosaic disease.

During the present year, the technique developed during 1932 has been applied to a study of the relationship between light, temperature and assimilation rate of the seedling tomato, variety E.S.1. It has been shewn that the assimilation rate falls steadily from mid-summer to the period around the shortest day and that there is a marked seasonal variation in the assimilation rate. The relationship between light, temperature and assimilation is complicated, and can

be illustrated best by means of a three dimensional model, one of which has been constructed. From this model it is possible to determine the optimum temperature for assimilation at a given light intensity.

The water content of the tissues has also been shewn to exert a profound influence on assimilation and tends to be too high in winter and too low in summer.

New methods have been evolved for the investigation of the part played by water in the economy of the tomato plant, and it is now possible to investigate tension of the cell wall, osmotic pressure of the cell sap and water content of tissues in a manner that has hitherto been considered impossible. Investigations along these lines are in progress. The preliminary investigation of a device for obtaining a constant light record has been made and the construction of a permanent recorder is well advanced. This should be of a considerable value.

Preliminary studies of the conditions affecting translocation, leaf expansion and root development in the seedling tomato have been completed but the data have not yet been examined critically.

Work has been continued on the nitrates in tomato soil. Some evidence has been obtained to show that excess of nitrate depresses the activity of the factor causing the disappearance of nitrates. In view of the beneficial effects of a first application of spent hops on the tomato crop the fluctuations in nitrates in a spent hop plot were followed. In this plot nitrates were always higher than in an untreated plot and in a plot containing peat. It may be of significance that the moisture content of the soil was always highest where spent hops had been added.

The effect of the omission of nutrients on the nitrogen contents of some market garden crops have been examined. In chrysanthemums and beet root omission of nitrogen, phosphates or potash depresses the nitrogen content. Omission of potash did not depress the nitrogen content of cabbage foliage, beet foliage, and carrot roots. Omission of phosphates did not depress the nitrogen content of runner bean foliage and pods and carrot foliage.

DIRECTOR'S REPORT.

1. Experimental Results of 1933.

1. Tomatoes.

Growers of glasshouse produce in this country are likely to regard the year 1933 with somewhat mixed feelings. For some it was a year of heavy tomato crops from strong healthy plants which never gave a moment's anxiety from start to finish. For others, the first half of the season gave promise of heavy crops but root trouble appeared towards the middle of July, causing premature death of the plant and low yields. For all it was a year of low prices.

Those who planted early, whose plants were well established before the hot spring weather arrived, obtained good crops; where planting was followed almost immediately by the hot weather, the plants made luxuriant vegetative growth out of all proportion to root development. Such crops were unable to stand the strain imposed by the abnormal summer weather, owing to badly developed and diseased root systems.

The intensely hot and sunny weather was most interesting from the experimental standpoint, as it provided confirmation of previous results, which suggested that during such weather the tomato crop benefits from liberal applications of nitrogenous fertilisers; also that during the height of summer, the provision of some shade is necessary.

In the experimental houses, regular dressings of a dried blood mixture were given and the glass was shaded from the middle of June onwards. Unusually heavy crops were obtained. Growers should bear such treatments in mind, for they will prove helpful during real summer weather. Generally speaking, the fruit was on the small side during 1933, and there was an unusual amount of "green back." Further there were many complaints of fruit arriving in the market in soft and badly coloured condition. Some experiments were made in this connection, and are discussed later in this report.

The practice of grading the tomato fruits from the experimental plots, adopted in 1921, was continued during the present season. The fruits were collected in numbered baskets and graded in eight grades as follows:—

A.—"Pinks" number 5 to 7 and "Pink and White" 8 to 10 to the lb. These are the best quality of fruit in size, shape and colour; "Pinks" being slightly larger than "Pink and Whites."

B.—"Whites." These fruits are of good colour but smaller than "Pink and White."

C.—"Blues." This grade consists of fruits of good colour but larger and more irregular in shape than Grade A.

D.—"Roughs." Small mis-shapen fruits about the size of cherries.

E.—Blotchy fruits which ripen irregularly.

F.—Fruits shewing Blossom End Rot.

G.—Fruits shewing the lesions of Stripe Disease.

H.—Fruits shewing "Green Back."

(a) Houses 3 and 4. Fertiliser experiment.

The experiment in these two houses was designed to test the effect of different nitrogenous compounds upon crop yield and quality of the fruit. These were sulphate of ammonia, nitrate of soda, cyanamide, nitrate of lime, dried blood, peruvian guano, fish meal, shoody, hoof and horn. Cyanamide, hoof and horn, and shoddy were applied as a single dressing before planting; of the others, a small portion was given before planting and the remainder in fortnightly applications from the middle of June onwards. The weight of fertiliser applied in each case was such that each plot received the same amount of nitrogen.

The results of the 1933 experiment are given in Table 1, and those of the past four years in Table 2.

Under the conditions of the experiment, similar results have been given by sulphate of ammonia, nitrate of soda and nitrate of lime. Peruvian guano, dried blood and fish meal, also behaved alike except in bright sunny summers, when dried blood and fish meal seem preferable to peruvian guano; and these three seem more suitable than sulphate of ammonia, nitrate of soda and nitrate of lime, when applied throughout the entire season as was done on this experiment. The question of the time of application is most important and will be investigated later.

Variety—"Ailsa Craig." **Table 1.**

House	Plot	Compound Tested	Crop in Lbs. per Plant								Total Tons per Acre	Average Tons per Acre
			May	June	July	Aug.	Sept.	Oct.	Nov.	Total		
3	1	Sulphate of Ammonia ...	0·59	1·58	2·23	0·69	0·54	0·51	0·15	6·23	47·36	47·30
	5	,, ,, ,, ...	0·21	2·01	2·57	0·87	0·39	0·33	0·07	6·42	48·79	
	14	,, ,, ,, ...	0·39	1·75	1·89	0·85	0·50	0·51	0·13	6·02	45·75	
	6	Nitrate of Soda	0·23	2·15	2·61	0·98	0·53	0·49	0·11	6·60	50·16	47·70
	9	,, ,, ,, ...	0·26	1·80	2·83	1·05	0·47	0·22	0·09	6·32	48·04	
	13	,, ,, ,, ...	0·29	1·73	1·69	1·05	0·57	0·56	0·12	5·91	44·91	
	8	Cyanamide	0·15	1·91	2·72	1·16	0·53	0·32	0·16	6·92	52·51	51·41
	11	,, ...	0·35	2·02	2·72	0·99	0·35	0·24	0·09	6·76	51·36	
	15	,, ...	0·68	1·76	1·93	1·06	0·65	0·55	0·14	6·63	50·37	
	3	Nitrate of Lime	0·33	1·99	2·23	0·97	0·57	0·51	0·15	6·75	51·30	48·76
	7	,, ,, ,, ...	0·24	2·09	2·33	1·43	0·49	0·39	0·13	7·10	53·95	
	16	,, ,, ,, ...	0·54	1·54	1·86	0·89	0·54	0·13	—	5·40	41·04	
	2	Hoof and Horn	0·47	1·87	2·45	0·66	0·52	0·48	0·08	6·38	48·50	48·61
	4	,, ,, ,, ...	0·21	1·95	2·30	0·95	0·33	0·46	0·08	6·29	47·82	
	10	,, ,, ,, ...	0·32	2·03	2·85	1·02	0·44	0·24	0·15	7·11	54·03	
	12	,, ,, ,, ...	0·30	1·76	2·21	0·90	0·31	0·35	0·09	5·92	44·09	

Table 1 *(continued).*

House	Plot	Compound Tested	Crop in Lbs. per Plant								Total Tons per Acre	Average Tons per Acre
			May	June	July	Aug.	Sept.	Oct.	Nov.	Total		
4	7	Dried Blood	0·46	2·22	2·43	0·78	0·26	0·27	0·03	6·43	48·86	46·36
	12	,, ,, ...	0·45	1·81	2·18	0·83	0·27	0·19	0·04	5·77	43·86	
	4	Hoof and Horn	0·64	1·55	1·71	0·83	0·39	0·42	0·05	5·59	42·48	44·72
	10	,, ,, ,, ...	0·51	1·87	2·59	0·75	0·23	0·21	0·05	6·18	46·96	
	5	Peruvian Guano	0·48	1·95	1·86	0·67	0·43	0·33	0·03	5·77	43·85	44·38
	9	,, ,, ...	0·46	1·78	2·16	1·07	0·24	0·16	0·04	5·91	44·91	
	8	Fish Meal	0·40	1·97	2·57	0·80	0·20	0·28	0·02	6·22	47·27	45·64
	11	,, ,, ...	0·51	1·58	2·38	0·89	0·23	0·17	0·03	5·79	44·00	
	6	Shoddy	0·50	1·94	2·45	0·77	0·39	0·33	0·04	6·42	48·78	46·66
	13	,, ...	0·68	1·51	1·82	1·07	0·40	0·31	0·07	5·86	44·53	

Variety—"Ailsa Craig."

Table 2.

House	Compound Tested	1930		1931		1932		1933		Average Tons per acre of the four years
		Average Tons per Acre	Relative	Average Tons per Acre	Relative	Average Tons per Acre	Relative	Average Tons per Acre	Relative	
3	Sulphate of Ammonia ...	31·79	89	24·86	103	38·27	106	47·30	97	35·5
	Nitrate of Soda	32·28	94	22·42	93	34·59	96	47·70	98	34·3
	Cyanamide...	33·67	97	26·99	114	36·75	101	51·41	118	37·2
	Nitrate of Lime	34·77	100	24·10	100	36·00	100	48·76	100	37·7
	Hoof and Horn	—	—	—	—	—	—	48·61	100	—
4	Hoof and Horn	37·09	100	35·27	100	38·84	100	44·72	100	39·0
	Peruvian Guano	33·87	91	31·01	88	34·88	89	44·38	99	36·0
	Shoddy	35·00	94	30·90	87	37·43	96	46·66	104	37·5
	Dried Blood	36·22	97	32·15	91	34·35	88	46·36	103	37·2
	Fish Meal	33·55	90	37·13	105	37·88	97	45·64	102	38·5

As a base dressing, hoof and horn was slightly better than cyanamide during the first year and better than shoddy for the first three years; in the fourth year the yield from the shoddy plot exceeded slightly that from the hoof and horn plot. Shoddy decays slowly in the soil and the cumulative effect of yearly dressings is valuable.

The results obtained from cyanamide demand further investigation. This compound has an injurious effect upon plant life during at least three weeks after application; it may possess certain sterilizing properties which could be used to advantage in glasshouse work.

(b) Planting the trenches.

This experiment was started in 1932 to see if any improvement in crop and lasting power of the plants could be obtained by planting in shallow trenches and filling these up later to encourage the development of a new root system above the original. It will be remembered that this experiment was suggested as the result of top dressing one of the experimental houses, in 1931, with a six inch layer of turf in fairly large lumps.

The trench experiment has not been a success, because although it was possible in induce the formation of new roots, it is difficult to fill up the trenches sufficiently early in the year, owing to the presence of the fruit on the lowest trusses. Further, it is not good practice to plant in the bottom of trenches when the soil is heavy and cold, for these conditions injure the roots during the early stages of growth to such an extent that the effect is felt throughout the greater part of the season. In lighter and warmer soils than those of the experimental station, this practice may prove beneficial.

The results of the present year's experiments are given in Table 3.

(c) Variety Trials.

The variety trials which were continued in House 5 included some of the newer varieties and the progeny of certain crosses made in previous years.

The results are given in Table 4.

It is interesting to note the abnormally high yields which were obtained from all varieties, owing to the unusually favourable weather conditions.

Table 3.

Variety—E.S. 1.

House	Plot	Treatment	Crop yield in Lbs. per Plant								Total Tons per Acre	Average Tons per Acre
			May	June	July	Aug.	Sept.	Oct.	Nov.	Total		
2	1	Normal planting	0·86	1·55	2·16	0·89	0·50	0·17	—	6·23	47·35	38·16
	6	,, ,, ...	0·66	1·70	2·05	0·82	0·31	0·12	—	5·66	43·01	
	14	,, ,, ...	0·56	1·36	1·67	0·63	0·32	0·18	—	4·72	35·87	
	2	,, ,, ...	0·58	1·17	1·71	0·64	0·27	0·14	—	4·51	34·27	
	7	,, ,, ...	0·40	1·47	1·73	0·74	0·22	0·11	—	4·37	33·22	
	13	,, ,, ...	0·52	1·51	1·55	0·62	0·28	0·16	—	4·64	35·26	
	3	Planted in a trench, later filled up with half peat and half house soil	0·57	1·39	1·86	0·65	0·34	0·15	—	4·87	36·94	36·73
	8	,, ,, ,, ,, ,, ,, ,, ,,	0·19	1·52	1·96	0·67	0·22	0·10	—	4·66	35·42	
	12	,, ,, ,, ,, ,, ,, ,, ,,	0·42	1·55	1·92	0·73	0·25	0·20	—	4·98	37·84	
	4	Planted in a trench, later filled with peat and covered with soil from the house ...	0·56	1·16	1·96	0·68	0·27	0·12	—	4·75	36·10	36·65
	11	,, ,, ,, ,, ,, ,, ,, ,,	0·37	1·48	1·71	0·78	0·22	0·23	—	4·79	36·40	
	16	,, ,, ,, ,, ,, ,, ,, ,,	0·63	1·17	1·67	0·80	0·39	0·27	—	4·93	37·46	
	5	Planted in a trench, later filled with soil from the house	0·49	1·00	1·65	0·82	0·42	0·16	—	4·56	34·65	35·64
	10	,, ,, ,, ,, ,, ,, ,, ,,	0·28	1·51	1·83	0·77	0·21	0·15	—	4·75	36·10	
	15	,, ,, ,, ,, ,, ,, ,, ,,	0·56	1·23	1·79	0·72	0·34	0·22	—	4·76	36·17	

Variety Trial.

Table 4.

Variety	Crop Yield in Lbs. per Plant							Total Tons per Acre	Quality of Fruit: Percentage in Grade.			
	May	June	July	Aug.	Sept.	Oct.	Total		A.	B.	C.	D.
Radio (1)	0.69	1.99	2.93	1.19	0.60	0.20	7.60	57.76	68	16	15	1
Radio × Kondine	0.91	1.94	2.41	1.29	0.42	0.12	7.09	53.88	71	15	12	1
Radio (2)	0.98	1.70	2.39	1.19	0.36	0.30	6.92	52.70	71	17	10	1
E.S.1. × Sunrise type	0.73	1.86	2.59	1.24	0.25	0.16	6 83	51.91	78	14	3	2
Kondail	0.45	1.91	2.23	1.36	0.33	0.22	6.55	49.78	77	12	9	2
Kondail	0.99	1.67	1.72	1.23	0 35	0.38	6.34	48.18	46	10	42	2
Tuckswood × Up-to-date	0.22	1.48	2.44	1.30	0.57	0.30	6.31	47.98	37	12	47	2
Potentate	0.99	1.93	1.68	1.11	0.42	0.14	6.27	47.65	40	10	48	2
Blaby Special	0.79	1.57	2.09	1.09	0.43	0.29	6.26	47.58	46	12	40	1
Shevada Gem	0.62	1.79	2.27	0 91	0.40	0.17	6.16	46.82	70	20	8	1
Bides Recruit	0.57	1.75	2.27	1.00	0.38	0.17	6.14	46.66	72	23	4	1
Paul's No. 12	0.67	1.75	2.05	1.23	0 31	0.13	6.11	46.44	70	19	6	3
Up-to-date	0.30	1.88	2.04	1.03	0.56	0.30	6.11	46 44	30	11	57	2
Best of All × Comet (U.S.A.)	0.51	1.69	1.94	1.21	0.40	0.27	6 02	45.75	52	6	35	1
E.S.1. × Morley's Pride, F.1.... ...	1.01	1.11	2.28	0.91	0 36	0.25	5.92	44.99	67	15	7	1
E.S 1. × Tuckswood	0.62	1.68	2.10	1.05	0.21	0.15	5.81	43.90	60	19	18	2
Franklin Fern	0.62	1.71	1.69	0.98	0.44	0.17	5.61	42.64	56	8	33	1
E.S.1. × Potentate, F.1.	0 88	1.35	1.71	0.90	0.39	0.27	5.50	41.80	69	16	13	2
E.S.1. × Shevada Gem, F.1.	0.67	1.19	1.94	1.07	0 30	0.29	5.41	41.12	68	20	8	4
E.S.3. × Finchley, F 2.	0.62	1.47	1.93	0.90	0 39	0.02	5.33	40.51	68	16	14	1
Helvetia	0.87	1.20	1.65	1.17	0.13	0.08	5.10	38.80	78	11	8	2
Crystal × American Pink	0.50	1.47	1.60	1.04	0.18	0 12	4.91	37.32	60	15	24	1

Varieties of the Kondine Red type which are so popular in Guernsey have done extremely well. The same applies to Radio, Radio × Kondine Red and Kondail. Whether the last three varieties will do so well under normal summer conditions remains to be seen, and it will be necessary to continue the trials for several years.

A considerable advance has been made with the types resistant to leaf mould, which were also grown in House 1. In this house the heaviest crop, 48 tons per acre, was obtained from Tuckswood × Up-to-date, but the quality was not completely satisfactory for there was a large proportion of irregular fruit. In the case of E.S.1. × Stirling Castle the crop was not so heavy but the quality of the fruit was good.

The work on these resistant varieties is being continued; the attempt is being made to improve root development and type of fruit by further hybridization and selection.

(d) Investigations on the reduction in yield of the tomato crop by continuous cultivation in the same soil.

In the Annual Report for 1931, the results of this series of experiments between 1923 and 1931 were reviewed. The rate at which the crop decreased as the result of cultivating tomatoes in the same soil, year after year, was discussed and it was suggested that, apart from the influence of the plant itself, the reduction in yield appeared to be connected with the continual use of horse manure and the destruction of coarse organic material which is so necessary to keep the soil in suitable physical condition and also supply food for the growth of soil organisms.

In these experiments the use of such materials as clean straw, peat, spent hops and chrysanthemum roots have been tested during several years, as a means of counter-acting the continual reduction in crop and raising the yield to its original level.

The results of the present year's experiments are given in Table 5, and it is now possible to discuss the value of each of the above materials.

Peat.

The incorporation of peat with tomato soils, especially those of medium and heavy types improves the mechanical condition of the soil, producing a corresponding improvement of root growth and an increase in yield. Unfortunately, light dressings are insufficient to alter the physical conditions sufficiently; heavy dressings of 20 to 30 tons per acre are

Variety—E.S.1.

Table 5.

House	Plot	Treatment	Crop yield in lbs. per plant							Total Tons per Acre
			May	June	July	Aug.	Sept.	Oct.	Total	
7	1a	Chrysanthemum roots added 1931 and 1932	0.08	1.80	2.86	1.13	0.79	0.34	7.00	53.20
	1b	Chrysanthemum roots added 1931	0.07	1.72	2.42	1.09	0.64	0.36	6.30	47.88
	2	Peat C added 1931	0.06	1.85	2.89	1.36	0.65	0.39	7.20	54.72
	3	Control	0.08	1.84	2.69	0.89	0.50	0.26	6.26	47.55
	4	Control	0.07	1.76	2.94	1.18	0.77	0 32	7.02	53.35
	5	Control but soil heated	0.08	1 84	3 78	1.39	0.75	0.36	8.20	62.32
	6	Peat C, 1932: soil heated	0.02	1.34	2.68	1.38	0.53	0.34	6.29	47.80
	7	Control	0.04	1.30	2.68	1.40	0.69	0.33	6.44	48.94
	8	Chrysanthemum roots, 1933: soil heated	0.02	1.39	2.58	1.27	0.66	0.40	6.32	48 03
8	1	Control	0.01	1.36	2.04	0.45	—	—	3 86	29.33
	2a	Control	—	1.39	2.77	0.48	—	—	4.64	35.26
	2b	Treated peat	0.01	1.25	2 60	0.49	—	—	4.35	33.06
	3	Straw dug in 1932 and 1933	—	1 38	2.43	0.44	—	—	4.25	32 30
	4	Chrysanthemum roots, 1932, 1933	—	1.30	2 31	0.44	—	—	4.05	30.78
	5	Control	—	1.13	2.68	0.50	—	—	4.31	32.75
	6	Old tomato roots added 1931	—	1.25	2.59	0.28	—	—	4.12	31.31
	7a	Diseased Chrysanthemum roots added 1933 ...	—	1.29	1.56	0.22	—	—	3.07	23.33
	7b	Straw dug in 1933	—	1.42	2.54	0.35	—	—	4.31	32.75
	8	Control	—	1.75	1.93	0.25	—	—	3.93	29.87

Table 5 *(continued).*

House	Plot	Treatment	Crop Yield in lbs. per plant							Total Tons per Acre
			May	June	July	Aug.	Sept.	Oct.	Total	
9	1	Control	—	1.27	2.30	0.91	0.66	0.41	5.55	42.09
	2	Dichlorphenol in the subsoil, 1932	—	1.15	2.68	0.94	0.88	0.43	6.08	46.18
	3	Peat A added 1932	—	1.31	3.01	1.26	0.72	0.39	6.69	50.83
	4	Peat B added 1932	—	1.12	3.00	1.32	0.72	0.36	6.52	49-54
	5	Peat C added 1932	—	1.07	3.69	1.42	0.93	0.43	7.54	57.29
	6a	Chrysanthemum roots added 1932, 1933	—	0.95	2.71	0.91	0.51	0.38	5.46	41.49
	6b	Straw dug in, 1932, 1933	—	1.01	2.93	1.04	0.55	0.35	5.88	44.67
	7	Formaldehyde in the subsoil, 1932	—	0.93	2.65	1.20	0.42	0.43	5.63	42.78
	8	Peat B added 1932	—	0.94	2.65	1.06	0.50	0.42	5.57	42.32
10	1	Peat A added 1933: soil heated	—	0.96	2.36	1.29	0.68	0.43	5.72	43.46
	2	Spent hops added 1933: soil heated	—	0.90	2.27	1.25	0.61	0.36	5.39	40.95
	3	Control: soil heated	—	1.35	3.07	1.22	0.80	0.39	6.83	51 89
	6	Control: soil heated	—	1.42	3.80	1.68	0.71	0.39	8.00	61.03
	7	Spent hops added 1932, 1933; soil heated	—	0.88	2.71	1.47	0.64	0.39	6.09	46.26
	8	Peat A added 1932, 1933: soil heated	0.02	1.08	3.06	1.51	0.76	0.47	6.90	52.43

necessary. This, combined with the relatively high cost of peat in this country, will probably restrict its use by tomato growers. It must not be imagined that any kind of peat is suitable; some types tested in the experimental houses produced injurious effects despite the fact that they were only slightly acid. To be satisfactory, the peat should be in a friable condition and not in lumps, unless these can be broken down before use. In considering the use of a new source of peat, growers would be advised to test it on a small scale during a year before making extensive applications. It must be remembered that as the feeding value of peat is practically negligeable, the usual fertilisers must be applied also.

Spent Hops.

Spent hops might be expected to prove useful material for improving tomato soils. Their application almost invariably increases the yield during the first year but in the soil of the experimental station spent hops break down to a very fine condition, so that the beneficial effect is not maintained during the second year. Indeed the second year's crop has been lower than that of the control plots. This being so, the use of spent hops cannot be recommended to tomato growers until this material has been tested on a larger scale.

Chrysanthemum Roots.

Excellent results have been obtained after digging chrysanthemum roots into the soil of tomato houses, when the material has been free from disease. The results of the present experiments in which diseased material was purposely used has shewn very definitely that such chrysanthemum roots are injurious to the crop of tomatoes which follows.

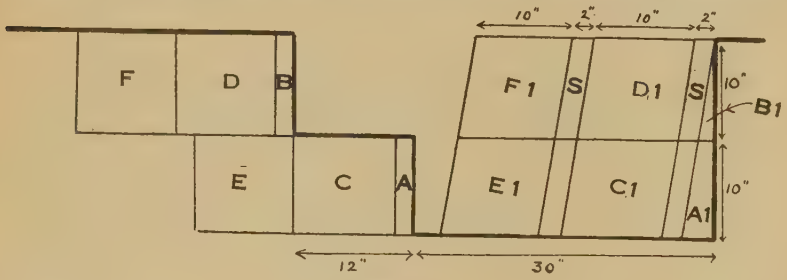
This being so, having regard to the difficulty of selecting the right material, it is not safe to recommend chrysanthemum roots for general use.

Clean Straw.

The use of clean straw as a means of improving tomato soils is one which can be recommended to growers on medium and heavy soils. It has been tried on many nurseries in different parts of the country with satisfactory results. Where the first year's treatment does not show a marked improvement, it should be continued during several years.

The manner of placing the straw in the soil is most important, for if it is merely laid on the ground horizontally and dug in as so much horse manure, the full benefit is not obtained; indeed no difference in crop may be observed.

To be most effective it must be placed almost vertically in both top and second spits. Trussed straw is better than baled straw, for the individual straws are not crushed and serve as tubes along which the air can circulate. The straw must be sufficiently long to extend the full depth of the trench. It may be cut in suitable lengths or used uncut by bending the straw at the centre. Wheat or oat straw is to be preferred. The rate of application is six tons per acre for a depth of 20 inches; the most convenient way of applying it is by the process of bastard trenching as shewn in Fig. 1. In this way a wall of straw about 2 inches thick is placed between walls of soil 10 inches thick, keeping the top and second spits in the proper position.



S =Straw. **Figure 1.**

The effect of the straw is two-fold. It renders the soil more open and makes it more suitable for root development. It also changes the condition in which nitrogen exists in the soil, and when the land is not abundantly supplied with nitrogen, symptoms of nitrogen starvation may appear in the following crop; this can be corrected easily by top-dressing. Growers, therefore, should regard this process as a means of improving and to some extent cleaning the soil, not as introducing a fertiliser, for in some cases the usual manurial treatment must be applied in addition to the straw.

Where the soil has been liberally manured during many years, it is rich in fertiliser residues; it may then be sufficient to add straw and sulphate of potash only, during the first year but later horse manure and the usual fertilisers should also be applied.

On new soils and on those which are not so rich, horse manure and fertilisers must be given even during the first year. It is convenient to add all three and also, if necessary, to sterilize with formaldehyde at the same time. For this purpose the requisite quantity of horse manure is spread over the surface of the soil or else placed in heaps upon it. A wall of straw is placed in position as shewn above. The fertiliser is sprinkled over the top half of it. The manure is then picked

up with the soil and placed against the straw as detailed previously. Formaldehyde solution is then applied in sufficient quantity to saturate both the soil, manure and the straw. When the process is finished, pieces of straw will be left here and there sticking up above the soil surface. It is essential to water heavily afterwards, as the straw must be thoroughly wetted before introducing the tomato plants. This can be done at once, unless formaldehyde has been applied when the watering should be deferred two or three weeks.

(e) Soil heating.

The process of warming the soil by buried hot water pipes was investigated further. For this purpose a separate hot water boiler was installed and a series of two inch pipes were buried in House 10, on the gravity system. The pipes were laid in the soil 2 feet 6 inches apart on the east side and 1 foot 6 inches apart on the west side of the house. At the lowest end they were 20 inches deep rising to a depth of 14 inches below the surface at the highest end. It was difficult to maintain a uniform soil temperature because control had to be applied at the boiler, but so far as can be determined the soil temperature on the west side was approximately 80° to 85°F., and on the east side it was 70° to 75°F. The following results were obtained:—

Average of three plots 70°—75°F. = 45·43 tons per acre.
„ „ „ „ 80°—85°F. = 53·24 „ „ „
„ „ „ „ in adjoining house 60°—70°F. = 42·40 tons per acre.

This house is eleven years' old and has never been sterilized. Last year the average yield was 35·9 tons per acre for the whole season, whereas the adjoining plots used as the control on the above experiment produced 50 tons per acre. The yield was so low, and the roots of the plants so badly decayed that the house should have been sterilized. The results confirm the beneficial effect of high soil temperatures, and suggest that soil heating may replace sterilization to some extent.

In House 7 another soil heating experiment was conducted. In this case the soil was heated by circulating hot water through pipes 1 inch in diameter. These were buried 18 inches apart, 12 inches below the surface. They were connected to the hot water pipes used for heating the air, and the water was circulated by means of an electrically driven pump, regulated by a soil thermostat. In this way circulation was continued until the soil temperature rose to 80°F., when the pump ceased to function, but restarted when the soil temperature fell below 80°F.

The disadvantage of this system is that while the water in the ordinary hot water pipes is kept at a high temperature during the night, it is allowed to cool during the day, which means that the water circulated through the buried pipes is sufficiently hot, only during the night.

In this experiment soil heating was not started until three weeks after planting, after which a soil temperature of 80°F. was maintained. In previous experiments, where the soil has been heated before or at planting time, the crop increase has been observed in May and June, but in this experiment it did not show until July. The crop yield for the whole season was 62·32 tons per acre from the heated plot and 53·35 tons per acre from the control.

The results of seven years experiments have shewn very clearly that when the soil temperature is raised to 80°F. during the first three months of the season there is a definite improvement in the crop. Root development is greater, and the roots are cleaner than at ordinary temperatures. Vegetative growth is more vigorous and the plants last longer. Although the first box of fruit is not usually picked earlier, the crop ripens more quickly and a greater quantity is picked during the first month. Much of the root trouble, to prevent which soil sterilization is employed is the result of unsuitable physical and chemical conditions in the soil. These appear to be overcome by raising the soil temperature. Further a warm soil would prevent infection by *Verticillium albo-atrum.* On the other hand, eelworm attack would be intensified in a hot, dry soil.

The work on soil heating has now passed beyond the experimental stage and it is hoped that some nurserymen will test the process themselves on a small scale.

A suitable apparatus includes (1) a hot water boiler for providing water at a temperature of about 140°F.; (2) an electrically driven pump fitted with a starting device controlled by a soil thermostat; (3) a quantity of 1 inch piping and (4) a water storage tank to prevent overheating of the boiler when the pump is out of action. The pipe should be treated specially to prolong its life in the soil, and should be buried 20 to 24 inches below the surface, allowing 2 feet between the pipes. Provision is thus made for digging the soil without interference, and it appears advantageous to place the pipes at this depth rather than nearer the surface.

It is suggested that a soil temperature of 70—73°F. should be maintained from planting time until the first truss has begun to swell, when it should be increased to 80°F. No additional benefit has been observed when heating is continued beyond the twelfth week after planting.

Variety—E.S. 1.

Table 6.

House	Plot	1928		1929		1930		1931		1932		1933	
		Treatment	Tons per acre	Treatment	Tons per acre	Treatment	Tons per acre	Treatment	Tons per acre	Treatment	Tons per acre	Treatment	Tons per acre
11	1	No Lime	54·49	No Lime	43·70	Lime	40·51	Lime	45·82	Lime	44·43	Lime	44·54
	3	,, ,,	52·28	,, ,,	48·94	,,	42·56	,,	48·34	,,	44·44	,,	49·14
	2	,, ,,	53·57	,, ,,	47·19	No Lime	37·46	No Lime	56·70	No Lime	44·49	No Lime	47·83
	4	,, ,,	50·56	,, ,,	45·07	,, ,,	43·39	,, ,,	42·71	,, ,,	45·01	,, ,,	46·66
12	1	Lime*	43·02	Lime	40·73	Lime	28·35	Lime	32·53	Lime	—	Lime	35·76
	3	,,	38·30	,,	30·48	,,	22·51	,,	35·27	,,	—	,,	37·82
	2	,,	41·72	,,	37·39	No Lime	25·31	No Lime	36·79	No Lime	—	No Lime	41·38
	4	,,	40·88	,,	36·40	,, ,,	29·64	,, ,,	34·43	,, ,,	—	,, ,,	40·78

* Caustic lime: 2 tons per acre.

A full account of this work was published in the Journal of the Ministry of Agriculture.*

(f) Liming experiment.

The liming experiment in Houses 11 and 12 was continued and it is now possible to summarise the results of the past six years. These are given in Table 6.

It will be readily seen that under the conditions which exist in the experimental houses the crop yield has not been increased as a result of liming the soil. Plots 2 and 4 in House 11, have never received lime since the houses were erected, and the soil is definitely sour, despite which a crop of 46 to 47 tons per acre was obtained this year.

It would seem, therefore, that the need for liming tomato soils has been over estimated in the past and that the tomato can tolerate a certain degree of acidity, although it seems that acid compounds which occur in some soils can cause injury.

As a general rule heavy applications of lime do not seem desirable, except in the case of heavy clay soils, when it is necessary to improve the physical condition.

2. Cucumbers.

The experimental work with cucumbers was concerned with the question of soil temperature. This work was begun in 1931, when a system of buried cables, heated by the passage of an electric current, was laid underneath the beds. The experiment, as in the case of tomatoes shewed that the crop may be hastened and increased by maintaining the beds at a temperature of about 90°F. during the night.

In 1932, the experiments were continued on a larger scale. Some of the beds were prepared from virgin turfy soil and horse manure over the normal base, and others from sterilized soil and horse manure over a sterilized base. The results suggested that the beneficial effect of raising the temperature of the beds, is greatest when the soil had not been sterilized, but as soil sterilization invariably increases the yield, the heated and sterilized soil gave a bigger crop than the heated and unsterilized soil. It was further suggested that when the beds are heated the plants are not so badly affected by injurious agencies present in the unsterilized base.

The present experiments were arranged to test the effect of heating both sterilized and non-sterilized beds, heat being applied between 10 p.m. and 6 a.m.; the average temperature was 90° to 95°F.

* Vol. XL., No. 11, February, 1934, p.p. 1047—1056.

Table 7.

Variety—"Butcher's Disease Resister."

House	Plot	Treatment for 1933.	Pounds per plant								Total Tons per acre	Total Flats per foot
			March	April	May	June	July	Aug.	Sept.	Total		
C	1	Soil not sterilized: normal Treatment ...	0·47	12·63	13·38	10·91	11·59	2·98	—	51·96	77·94	1·61
	2	,, ,, ,, ,, ,, ...	0·21	13·39	13·15	10·48	10·05	1·19	—	48·47	72·71	1·50
	3	,, ,, ,, ,, ,, ...	0·82	10·80	13·00	11·83	11·23	2·68	—	50·36	75·54	1·56
	4	,, ,, ,, ,, ,, ...	0·77	13·61	14·50	11·21	10·57	2·52	—	53·18	79·77	1·64
D	6	Soil not sterilized	2·13	15·73	15·94	11·60	11·17	5·12	0·44	62·13	93·20	1·92
	2	Soil sterilized; bed heated...	1·50	17·22	15·54	13·50	11·00	5·11	1·13	65·00	98·00	2·01
	3	,, ,, bed not heated	1·46	17·25	14·42	12·50	13·47	5·62	0·74	65·46	98·19	2·03
	4	Soil not sterilized; bed not heated ...	1·45	15·41	13·98	11·11	11·58	4·53	—	58·06	87·09	1·80
	5	,, ,, ,, bed heated	2·78	15·13	13·57	11·86	10·75	4·83	1·47	60·39	90·59	1·87
E	7	Soil not sterilized	1·22	14·53	13·13	11·35	11·02	2·54	—	53·79	80·69	1·66
	3	,, ,, ,, bed not heated ...	2·18	15·54	13·62	13·87	10·38	3·06	—	58·65	87·98	1·81
	4	,, ,, ,, bed heated	1·68	14·82	12·83	13·03	11·35	7·25	2·31	63·27	94·91	1·95
	5	,, ,, ,, bed not heated ...	1·57	15·21	12·55	12·58	11·82	3·83	1·33	58·89	88·34	1·82
	6	,, ,, ,, bed heated	1·62	15·98	13·94	12·53	11·81	6·00	—	61·88	92·82	1·92
F	6	Soil not sterilized	2·07	14·60	13·87	14·06	12·54	5·22	0·87	63·23	94·85	1·95
	2	Soil sterilized: bed heated	1·35	16·09	14·60	14·28	11·41	5·36	1·08	64·17	96·26	1·98
	3	,, ,, bed not heated	1·03	16·02	13·58	13·54	12·57	5·57	0·43	62·74	94·11	1·94
	4	Soil not sterilized: bed heated	2·08	13·36	15·46	14·31	11·81	5·54	1·02	63·58	94·89	1·96
	5	,, ,, ,, bed not heated ...	2·00	14·36	13·91	13·27	12·42	4·13	—	60·09	90·14	1·86

The results shewn in Table 7 confirm those of 1932, and suggest that, to some extent, sterilization may be replaced by soil heating. The differences between the best and worst plots are not so marked as during previous years; this can be accounted for by the general improvement in growth, as the result of the excellent weather conditions.

During the coming year the electrical method will be compared with others which entail the use of hot water pipes placed beneath the beds; it is hoped that it may be possible to make recommendations to growers of cucumbers similar to those already suggested for tomatoes.

3. Lettuce.

The cultivation of a lettuce crop in tomato houses during the autumn and winter offers great possibilities, as there is an increasing demand for this salad.

The market requires tender, well-grown and carefully packed heads, which must be well-hearted, and except at isolated periods which occur occasionally there is no demand for a lettuce consisting only of whorls of loose leaves. During the past six years, many different varieties have been tested and none has been found which will form a suitable heart during the months November to February. Indeed this period can often be extended to the middle of March. Of the present varieties Golden Ball, and some of the Gotte types are the best.

Realising the necessity for obtaining a new lettuce which would heart during the period of short days, it was decided to make some attempt to procure it, and it seemed that a lettuce which would combine the qualities of Golden Ball and the Gotte types might be suitable.

The work of hybridization which was planned for the spring of 1931, was suddenly stopped by the chance occurrence of a very mixed batch of Golden Ball which was grown during the winter of that year. In this batch of plants, only some 40 per cent. were true to type; the remainder were much darker in colour, and contained a small percentage of coarse leaved types, in which the rosette was open and the leaves lay almost parallel with the ground, often having a span of 16 inches across the plant from the tip of one leaf to the tip of the opposite leaf. One plant occured which was dark green in colour, with an abnormally solid heart, and few loose surrounding leaves. This was retained as plant No. 1. Between this plant and the large open plant described previously came a series of intermediate types. It may be noted in passing

that the proportion of marketable heads from the entire batch did not exceed 50 per cent. and the appearance of the crop was a clear indication that the variety had been accidentally crossed in the field. It may be observed further that during six years experience of Golden Ball both at the Station and on many nurseries this type of mixed growth has never been observed.

Finally, plant No. 1, and five other well-hearted plants were lifted, grown in 12 inch pots, and grown for seed. Seeds were secured from five of them; the sixth plant succumbed before flowering.

In 1932, the seeds from the five types were grown. None of the plots were true to type. No. 1 produced a proportion of a small but solid hearted type (Early Ball) together with a proportion of the Golden Ball type, and a large number of coarse abnormal types. It will be some time before the types can be separated.

No. 2, contained the Early Ball type and also an interesting cone-shaped form. No. 5 gave a large firm-hearted type of excellent colour, which matured earlier than the rest, and has been named Cheshunt Early Giant. It also contained a proportion of the small solid-hearted type. No. 3 was somewhat similar to No. 5 while No. 4, resembled No. 1.

Selected plants were again lifted and seed taken as before. This seed is being used for the winter of 1934, and although the variety is not quite pure, an attempt is being made to obtain sufficient seed for trial on a commercial scale during 1935.

A house of Cheshunt Early Giant was planted on October 5th, 1933, from seed sown on September 14th. A temperature of approximately 50°F. was maintained and the crop was marketed during Christmas week. It earned a very good report from the market, and competed favourably with imported produce. The average weight of the heads was about 5 ounces.

The work of further selection will be continued, but it is believed that even in its present state this variety constitutes a considerable advance, because it will heart well even during the short days of November and December.

If sown early in October and planted in the houses during early December it can be grown without heat until the middle of January. By applying heat then it can be cleared by the end of February. It is best, however, to maintain a temperature of 50°F. from planting.

4. Oil Fuel Experiments.

The oil-fired installation described in the Seventeenth Annual Report for 1931, was employed until the end of 1933. A block of five vinery type glasshouses, each 100 feet long and 28 feet wide with a total capacity of 116,000 cubic feet was used for the experiment. There were six rows of 4 inch pipes in each house, circulation being attained by the gravity system; an accelerator was not employed. It will be remembered that this apparatus was installed by Messrs. Shell-Mex, Ltd., and that the "Hope Quiet May" oil burner was very kindly loaned by Messrs. Hope's Heating & Lighting, Ltd., while Messrs. Hartley & Sugden, Ltd., supplied the "Oilex" boiler. Our grateful thanks are due to these three firms whose enterprise made this experiment possible.

The effect of the oil-fired system on one block of tomato houses was compared with that of an ordinary hand stoked anthracite tubular boiler, on another similar block. Heating was continued from the last week in February to the end of June and the figures given refer to this period.

The results of three years' experiments are given in Table 8, but the oil consumption is not included for 1931, because as this was the first year of the experiment an excess of oil was used in conducting a great number of unusual tests, and in giving practical demonstrations to various growers.

In attempting a comparison the value of the crop has been calculated from actual market returns making due allowance for the quality of the produce.

The cost of anthracite is based on a figure of 44/- per ton and the cost of oil on a value of 70/- per ton. The cost of stoking the boiler for heating one acre of glass is estimated at £30 for the 19 weeks.

During 1931 and 1932 the crop from the oil-fired houses commenced to ripen about seven days earlier than the others, but in 1933 picking began three weeks earlier. It will be seen that during the normal Lea Valley weather of 1932, oil firing shewed only a slight profit, but in 1933 the profit amounted to £210 per acre, which must be attributed to the abnormally sunny weather of 1933 in conjunction with temperature control during the night hours obtained with the oil-firing experiment.

The cropping power of the tomato is influenced to a considerable extent by the amount of available sunlight, heaviest crops being obtained during the sunniest years. Further the

Fuel Experiments.

Table 8.

Year	Kind of Fuel	Date of First Picking	Tons per Acre								Increased Value of Crop due to the use of oil	Amt. of Fuel	Cost of Fuel	Increased Cost due to use of Oil	Cost of Stoking	Profit per acre due to use of Oil
			May	June	July	Aug	Sept.	Oct.	Total	Value						
										£ s. d.	£ s. d.	Tons	£ s. d.	£ s. d.	£	£ s. d.
1931	Oil	22/5	0.69	13.07	16.64	7.68	6.46	2.74	47 28	1806 9 0	75 14 0	—	—	—	—	—
1931	Anthracite	29/5	0.23	12.59	15.88	6,08	5.40	5.09	45.27	1730 15 0	—	—	—	—	30	—
1932	Oil	27/5	0.30	12.59	9.96	7.60	5.40	2.89	38.74	1631 5 0	34 0 6	76.8	268 16 0	55 8 0	—	8 12 6
1932	Anthracite	1/6	—	9.04	14.59	8.13	4.33	2.66	38.75	1597 4 6	—	97.0	213 8 0	—	30	—
1933	Oil	12/5	5.78	12.39	15.96	6.54	3.12	1.14	44.93	1970 18 0	235 3 0	75.9	265 13 0	54 9 0	—	210 14 0
1933	Anthracite	2/6	—	8.06	20.22	7.45	4.71	3.04	43,48	1735 15 0	—	96.0	211 4 0	—	30	—

temperature of the houses must be regulated in relation to the amount of available sunlight. During dull weather the temperature must be reduced, but during sunny weather higher temperatures can be employed with advantage. It follows also that the tomato crop responds best to efficient temperature control in localities where abundant sunlight is available.

This explains why the oil-fired system which embodies accurate temperature control shewed a good profit during 1933, and a much less profit in 1932.

The oil-fired method will appeal to growers on the basis of its simplicity and efficient temperature control, which in addition to inducing an earlier crop, provides conditions which help to prevent attacks of certain leaf diseases, such as leaf mould of the tomato, a very important consideration.

The excellent results obtained during the past summer suggest that the oil-fired system will prove particularly useful in those districts such as the south and west coasts where abundant sunshine can normally be expected.

2. Mycological Investigations.

Diseases brought to the Station during the year and not previously reported are listed below:—

Host		
Antirrhinum ...	Rot of cuttings ...	*Rhizoctonia solani*
Apple	Twig blight ...	*Sclerotinia fructigena*
Chicory	Rot	*Bacillus carotovorus*
Chrysanthemum ...	Rot of cuttings ...	*Botrytis cinerea*
Gherkin	Mosaic	*Virus*
Gloxinia	Spotted wilt ...	*Virus*
Peach...	Scab	*Cladosporium carpophilum*
Primula malacoides	Spotted wilt ...	*Virus*
Primula sinensis ...	Spotted wilt ...	*Virus*
Sweet Pea	Powdery mildew ...	*Microsphaera alni*
Viola	Rot of cuttings ...	*Botrytis cinerea*
Zinnia	Foot rot	*Pythium sp.*

1. Leafy Gall of the Chrysanthemum.

P. H. Williams.

In the Eighteenth Annual Report for 1932, an account was given of the disease known as "Leafy Gall" of the Chrysanthemum. In this disease a dense mass of short, distorted shoots develops at the base of the stem in place of the shoots which are normally used for cuttings. Work on this disease has been continued during the past year.

Varietal susceptibility.

An examination of different varieties of Chrysanthemums grown at the Station was made during December, 1933. The results are given in Table 1. Where available, the corresponding figures for 1932 are shewn, a (†) sign denoting that the disease appeared in the variety but that the number of plants grown was too small for a significant estimate of the intensity of the disease to be made.

The disease also occurred in Mohawk, Reflexed Favourite, Golden Marvel and Susan. The number of plants grown in these varieties was too small for inclusion in the table. The disease did not occur in Claret and Golden Seal.

Table I.

Varietal susceptibility to Leafy Gall.

Variety	No. of Pots	No. Infected	Per cent. Infected	Per cent 1932
J. W. Streeter	38	22	57·9	†
Thanksgiving Pink ...	72	24	33·3	15·6
Crimson Conquest ...	78	23	30·2	16·6
Baldocks Crimson ...	110	10	9·0	7·7
Friendly Rival	103	9	8·7	18·6
Lady Churchill	61	4	6·5	—
Balcombe Beauty... ...	239	12	5·0	13·4
Chiltern White	81	4	4·9	0·
Favourite	140	6	4·2	7·9
December Bronze ...	52	1	1·9	—
Cheshunt White	124	2	1·6	2·1

The varieties J. W. Streeter, Thanksgiving Pink and Crimson Conquest shewed a high percentage of diseased plants, and the intensity of the disease was markedly higher than during the previous season. These varieties were grown at the Station for the first time in 1932, and as the stock was limited, every available cutting was taken. Where the number of plants was greater, as in Balcombe Beauty, Favourite and Cheshunt White, cuttings were taken from apparently healthy plants only. In these varieties, the amount of disease, already low, was still further reduced. These results suggest that the disease may be reduced to a very small amount by propagating only from healthy plants. Further evidence in support of this view will appear later in this report.

Inoculation Experiments.

Stem Inoculations.

A bacterium resembling *Bacterium tumefaciens* was isolated last year and its cultural characters described. This organism has again been isolated. When tomato stems were inoculated, the new isolations produced small swellings similar to those observed last year. An attempt was made to re-isolate the organism from these swellings. Certain of the cultures so obtained resemble the originals in appearance, but it has not yet been possible to compare their physiological reactions.

In the Chrysanthemum, the usual reaction was again a slight swelling at the point where the organism was pricked into the stem. With one strain the swellings were larger and may have been definite galls. In other cases they appeared to be wound reaction.

Soil Inoculations.

Three boxes of cuttings from healthy plants of Balcombe Beauty were rooted in sterilised sand and later they were potted up in sterilised compost. The sand and potting soil were inoculated with the Leafy Gall Organism and with *B. tumefaciens*. The method of inoculation was as follows:— Box 1 was saturated with 400 cc. of a mixed culture of six strains of the Leafy Gall Organism. After potting, ten plants received no further treatment in order to determine whether infection took place during propagation or later in the season. The remainder were treated by pouring 20 cc. of the mixed culture on the surface of the soil in each pot. This treatment was repeated seven times between March 30th and August 3rd. Box 2 was similarly treated with cultures of *B. tumefaciens*. Box 3, the control box, received sterile broth only. Diseased plants were removed to another house as soon as they appeared. All the plants were top-dressed several times during the season with a mixed fertiliser and with dried blood.

Up to November 3rd the controls showed no disease, although it had appeared in the inoculated plants. During November and December, however, the disease appeared and spread rapidly in the controls. The final results on December 21st are given in Table 2.

Table 2.

Inoculation of propagating and potting soils.

Inoculum	Infected	Healthy	Per cent. Infected
Leafy Gall Organism...	19 ...	10 ...	65·5
„ „ „ (Prop. soil only)	6 ...	3 ...	66·6
B. tumefaciens	13 ...	14 ...	48·1
„ „ (Prop. soil only) ...	5 ...	4 ...	55·5
Control	9 ...	9 ...	50·0

In a second experiment the soil was only inoculated after potting and received seven treatments. The results are shown in Table 3.

Table 3.

Inoculation of potting soil.

Inoculum	Infected	Healthy	Per cent. Infected
Leafy Gall Organism...	12 ...	12 ...	50·0
B. tumefaciens	15 ...	10 ...	60·0
Control	13 ...	11 ...	54·1

These experiments do not provide any clear evidence of artificial infection, although the first experiment suggests that it takes place, since the controls remained healthy for a long period. The last count made before the appearance of the disease in the controls showed 27·5% of diseased plants when inoculated with the Leafy Gall Organism and 28·5% with *B. tumefaciens*. In Experiment 2 the disease appeared throughout the season in approximately equal amounts in the inoculated and control plants. Plants of the same batch as those used in this experiment, but kept in a different chamber, only showed 30·4% of infected plants in place of 54·1%. There may, therefore, have been some accidental contamination of the controls although every care was taken to avoid it.

The plants which were exposed to infection in the propagating soil only shewed as high a percentage of infection as those in which the potting soil also was inoculated. This suggests that infection may take place at a very early stage, although the symptoms do not appear until the basal shoots commence to grow later in the season.

An attempt was also made to secure infection by dipping the cut ends of the cuttings in broth cultures of the Leafy Gall Organism and *B. tumefaciens*. The cuttings were then immediately inserted into moist sterilised sand. The control was the same as in the first experiment. The results are shown in Table 4.

Table 4.

Cuttings dipped in cultures.

Inoculum	Infected	Healthy	Per cent. Infected
Leafy Gall Organism	12 ...	13 ...	48·0
B. tumefaciens	5 ...	20 ...	20·0
Control	9 ...	9 ...	50·0

No infection took place, possibly owing to the small amount of inoculum used.

Control Measures.

Disinfection of Cuttings.

Normal shoots are often produced from infected plants and may be used for cuttings. An experiment in 1932 indicated that these cuttings give rise to infected plants. It was thought that if the disease was caused by a bacterium the surface of these shoots and of shoots arising from healthy plants in the same pot might be contaminated. It was hoped to eliminate the possibility of this infection by dipping the cuttings, after they had been made, in various fungicides.

The varieties used were Balcombe Beauty, Phyllis Cooper and Favourite. Jean Patterson, Mary Morris and Cheshunt White were also used, but sufficient were not available for them to be used in all tests. The substances tested were as follows:—

Cheshunt Compound ½ oz. per gallon.

Emulsified Cresylic Acid 1/1,000, 1/1,500 and 1/2,000.

Formaldehyde 1/200 (1 part 40% solution in 199 parts water).

Formaldehyde 1/400.

Uspulum 1/200 and 1/400.

Mercuric Chloride 1/1,500 and 1/2,000.

Twelve cuttings of each variety were made and then dipped for one minute in the appropriate solution, taking care that all were completely immersed. The cuttings were then immediately planted in sterilised sand. When rooted they were potted up in baked compost. During the summer they were placed outside on ash beds which had been soaked in formaldehyde. They were brought in again in the autumn. The plants were stopped twice and fed with either a mixed fertiliser or dried blood. They were examined at fortnightly intervals and diseased plants removed to avoid contamination.

The first galls appeared on May 3rd, but the majority did not appear until November and December. In the untreated controls, 57% of the Balcombe Beauty plants became diseased, while in the other varieties the amount of disease varied from 83% to 100%. In all treatments one or more varieties shewed some benefit, but the others were not affected. This method, therefore, does not appear to be of any value.

The effect of Sulphur and Calcium Sulphate in the soil.

Preliminary experiments were made in 1932 in which sulphur was mixed with the potting soil. In the present season these experiments were extended and calcium sulphate was also used. These substances were mixed at the rate of 0·25% by weight with soil from pots in which diseased plants had grown. These composts were then used for propagating. Owing to a shortage of clean stock, shoots from pots in which diseased plants had grown were used. The variety was Balcombe Beauty. After rooting, each series was divided into two lots one of which was potted in the same mixture. The other was potted in contaminated soil to which 0·125% of the appropriate substance had been added.

In the untreated soil, 76·3% of the plants became diseased. In both series with sulphur added the amount of disease was 88·1%, 0·25% calcium sulphate gave 52·9% of diseased plants and 0·125% calcium sulphate, 47.3%.

In a second experiment, cuttings of Balcombe Beauty from clean stock were propagated in sterilised sand and potted in contaminated soil to which sulphur and calcium sulphate had been added. Sulphur again did not reduce the amount of disease. 0·25% calcium sulphate shewed a reduction in the amount of disease from 30·4% to 20%, while 0·125% calcium sulphate shewed no benefit. Cheshunt White was also grown in this experiment and shewed no disease in the soils containing 0·25% of sulphur and 0·25% calcium sulphate, the smaller amounts having no effect on the disease. These results suggest that calcium sulphate may have some influence on the development of the disease and this substance will be tested further.

The use of clean stock.

Cuttings of Balcombe Beauty were obtained from clean stock and from healthy shoots from pots in which diseased plants had grown. All were propagated in sterilized soil and potted up in baked compost. 25·9% of the plants derived from apparently clean stock became diseased. When taken from contaminated stock, the cuttings gave rise to 78·4% of diseased plants.

This result supports the suggestion, made in considering the disease occurring in the main Chrysanthemum crop at the Station, that the use of clean stock leads to a marked reduction in the amount of the disease. A very high proportion of diseased plants of other varieties was also obtained when cuttings were taken from contaminated plants for the purpose of dipping in fungicides. The experiment will be repeated, and if the results can be confirmed, a promising method of controlling the disease will have been found. It is not possible to eliminate all slightly diseased plants before taking cuttings and, therefore, the complete control of the disease may not be possible. It should be practicable, however, to reduce it to negligible proportions.

Summary.

(1) Inoculation experiments with the bacterium isolated from Leafy Gall of the Chrysanthemum are reported.

(2) In experiments on the control of the disease, the incorporation of calcium sulphate with the soil has produced some reduction in the amount of the disease.

(3) The use of clean stock for propagating appears to be the most promising method of control.

2. Rose Diseases.

W. F. Bewley and O. B. Orchard.

(1) General.

In continuing the Rose investigations during 1933, an attempt was made to obtain some idea of the most important diseases which occurred in different parts of the country, both in glasshouses and in the open.

For this purpose a large number of diseased roses, kindly sent by rose growers were carefully examined.

Of the leaf diseases, the common powdery mildew, *Sphaerotheca pannosa* predominated, with rose rust, *Phragmidium subcorticium* a good second.

Where the death of the plant had been caused by fungal infection in the stem and roots, injury by *Coniothyrium rosarum* predominated, although *C. fuckelii* and *Diaporthe umbrina* also occurred. There was also a considerable amount of injury caused by *Botrytis* sp., especially in standard roses.

The amount of damage attributable to *Coniothyrium rosarum* was striking and suggests that attack by this organism is of such magnitude as to warrant a good deal of investigation.

It may be found, on further examination, that this disease must be considered in relation to rust, for plants weakened by the presence of *C. rosarum* seem particularly susceptible to rust, and may act as infection centres capable of starting this disease on adjoining plants.

The problem is being pursued further in this connection, and an attempt is being made to discover experimentally what conditions favour infection by *C. rosarum* with a view to devising preventive measures.

The past season seems to have favoured attack by *Botrytis* sp. especially among standard roses.

There a direct relationship between the amount of prevailing sunlight and the potash and nitrogen requirements of most plants which in general require a good deal of potash during dull rainy seasons and additional nitrogen during fine sunny summers like that of 1933. During the past year, drought and an insufficient supply of nitrogenous fertilisers led to the production of weak shoots towards the end of the summer. These were particularly susceptible to attack by *Botrytis* sp. and improvement was observed in many cases where the natural dryness of the soil was corrected by artificial watering and where applications of suitable nitrogenous fertilisers were made. Dried blood proved particularly useful in many instances.

(2) Rose rust. *(Phragmidium subcorticium.)*

In the experimental beds at Cheshunt, rust did not appear until the end of August and persisted until leaf fall early in November. During such a short period, experimental work is limited, and an attempt is being made to obtain information concerning this disease whereby the period of attack may be extended by inducing conditions favourable to the disease. For this purpose, rose bushes have been artificially inoculated with rust spores and submitted to as many different conditions as possible. It has been shewn that the severity of rust infection can be greatly increased by inducing conditions of high atmospheric humidity and moderately high temperatures. When heavy dew formation is induced the disease is particularly severe.

In arranging the above experiments, different stocks have been employed and some idea of stock resistance will be obtained at the conclusion.

Winter sprays.

A number of fungicidial compounds have been tested as sprays applied during the dormant season, with the object of determining if such treatment will prevent or delay the appearance of rose diseases.

For this purpose a number of plants in pots were pruned at the end of February, divided into batches and thoroughly sprayed with the following:—

Ammonium copper carbonate... ...	1 in 80*
Ammonium polysulphide	1 in 160
Burgundy mixture (4:5:40)	
Bordeaux 6:4:50	
Carbocrimp	1 in 32
„	1 in 64
Copper in oil compound	1 in 320
Cresylic acid	1 in 40
Colloidal copper compound	1 in 320
Colloidal sulphur compound	1 in 320
Eau celeste	1 in 50
Emulsified tar acid	1 in 500
Formaldehyde	1 in 50
Lime sulphur	1 in 50
Sulphuric acid	1 in 1500

* The above dilutions are by volume except Bordeaux and Burgundy mixtures.

None of these compounds, when applied during the dormant season caused any injury to the plant except carbocrimp at 1 in 32.

None of the treatments reduced or delayed the development of mildew and probably had no effect on rust.

Summer sprays.

Most of the common fungicides have been tested against rust as a summer spray.

In general, the copper compounds proved more effective than sulphur compounds. Many different wetting agents were tried in conjunction with the above, and while the sulphonated oil compounds increased the efficiency of the fungicidal fluids, the best results were obtained when certain copper compounds were carried in an emulsified oil.

In the latter connection promising results have been obtained, but the short duration of the rust attack prevented the trials from being completed. It is expected, however, that recommendations may be possible in time for the 1934 attack.

3. The sterilization of Lettuce Seeds.

H. L. White.

The treatment of many seeds with fungicidal liquids, powders and gases for the purpose of destroying disease organisms, which may be carried on the outer surface, has become increasingly popular, and approved methods of treatment are in general use. The application of such methods to vegetable seeds, especially lettuce, may result in serious seed injury. It was decided, therefore, as a preliminary to the study of lettuce diseases, that an attempt should be made to discover a reliable treatment which could be recommended to the commercial grower.

The effect of trials of fungicides at different concentrations and for different periods has been tested by (*a*) sowing treated seed in sterilized soil in seed trays, (*b*) germinating treated seed under a thin film of nutrient agar in sterile Petri dishes.

(A) Treated seed germinated in Petri dishes.

Formalin.

The results of treating samples of Golden Ball are shewn in Tables 1 and 2, the strength of the fungicide being given in terms of commercial formalin (40%).

Table 1.

Percentage germination. Untreated 58%.

Concentration Formalin	0.25%	0.5%	1.0%	2.0%
Time				
10 minutes	—	—	43	39
30 ,, ...	65	62	47	21
2 hours	42	10	1	0
24 ,, ...	0	0	—	—

Table 2.

Number of seeds with contaminated coats reckoned as percentage of those of controls.

Concentration Formalin	0.25%	0.5%	1.0%	2.0%
Time				
10 minutes	—	—	90	80
30 ,, ...	90	90	60	60
2 hours	80	60	40	10
24 ,, ...	20	10	—	—

Conclusions.

(1) Where either (1) concentration of formalin was increased (2) time of treatment was lengthened, the fall in percentage germination is steeper than that in number of contaminated seeds. No treatment that allowed germination gave anything like satisfactory clean seed.

(2) Low concentrations of 0·25% and 0·5% for long periods, such as 24 hours, retard the growth of bacteria but do not affect permanent sterilization. 2% for two hours is the minimum bactericidal dose at room temperature.

(3) Concentrations that have not injured the seed:—

0·25%	1—2 hours.
0·5%	45 minutes.
1·0%	30 minutes.
2·0%	10 minutes.

Since it appears that the minimum bactericidal period is twelve times that which will just not injure lettuce seed, it is concluded that sterilization by Formalin is unsuitable for lettuce seed.

Copper Sulphate.

Samples of Golden Ball were treated in accordance with the following scheme:—

0.75 Hour.	2 Hours.	4.5 Hours.
0·5%	0·5%	0·5%
1·0%	1·0%	1·0%
2·0%	2·0%	2·0%

In order to test the possibility of obtaining better sterilization by the removal of air bubbles adherent to the seed preliminary treatment with alcohol was carried out in a duplicate series. For the two shorter periods better sterilization was effected at all concentrations, whereas at the longer period preliminary alcohol treatment made no difference to the results.

Some of the results were as follows:—

Germination percentage.

Untreated 46%.

1% Cu SO 4 for 1 hour.

39
42
48
53
} 46%

No better than untreated seeds.

1% Cu SO 4 for 4·5 hours.

68
68
55
61
} 63%

Increase in germination of 37%.

2% Cu SO 4 for 4·5 hours.

22
33
39
36
} 33%

Decrease in germination of 28%.

Bactericidal effect.

Even 0·5% for 0·75 hour reduced the number of contaminated seeds by 50%.

Only three treatments reduced the number of contaminated seed to 10% of the untreated seed:—

2% for 1 hour; 1% for 4·5 hours; 2% for 4·5 hours.

Of these the last reduces the germination appreciably (see above) but the remaining two will be included in further tests. Whereas it may be possible to use copper sulphate for some lettuce varieties the margin of safety between the minimum bactericidal dose and the maximum dose tolerated by the seed is so small that this treatment cannot be considered satisfactory.

(B) Treated seed sown in seed trays.

The object of these trials was to ascertain the effect upon lettuce seed of treatments that have from time to time been recommended for the control of specific seed-borne diseases.

Over 6,000 seeds were sown in samples of about fifty. The following treatments were applied to each of three varieties:—

Trocadero; Gotte à Forcer; Golden Ball.

Dip Treatments.

Copper sulphate	1% for 1 hour.
Mercuric chloride	0·25% for 15 mins.
Uspulun	0·25% for 1 hour.
Formalin	0·25% for 30 mins.
Calcium hypochlorite ...	(to give 2% Cl_2) for 30 mins.

Dust Treatments.

Ceresan; Semesan; Tillantin R.; Copper carbonate; Cuprous oxide.

All the seeds treated by dips were washed in sterile water before sowing, but a duplicate series with copper sulphate, mercuric chloride, and uspulun was carried out in which the seeds were dried before sowing without washing.

The volume of dust to seed was approximately $\frac{3}{2}$. The relative adhesiveness of the dusts was found to be as follows:

Cuprous oxide. Very good. Seeds entirely coated.
Semesan.
Ceresan. } Satisfactory.
Tillantin R.
Copper carbonate. Very poor. Some seeds quite uncoated.

Germination.

Trocadero	%	Gotte à Forcer	%	Golden Ball	%
Untreated... ...	82	Copper Carbonate	79	Untreated... ...	92
Cuprous Oxide ...	82	Untreated... ...	78	Copper Carbonate	92
Copper Sulphate...	80	Copper Sulphate	78	Uspulun	92
Semesan	79	Uspulun	77	Copper Sulphate	90
Copper Carbonate	78	Tillantin R. ...	76	Formalin	89
Formalin	77	Cuprous Oxide ...	75	Cuprous Oxide ...	88
Uspulun	76	Calcium Hypo-chlorite	72	Calcium Hypo-chlorite	85
Calcium Hypo-chlorite	75	Formalin	71	Semesan	75
Tillantin R. ...	51	Semesan	67	Tillantin R. ...	37
Mercuric Chloride	2	Mercuric Chloride	51	Mercuric Chloride	1
Ceresan	0	Ceresan	8	Ceresan	1

Reductions in total germination which are statistically significant are separated by a line from those that are not. Injury less severe than that necessary to kill the seed is shown by retardation. Many treatments that did not shew final differences in germination would have done so had an earlier count been shewn. By plotting the daily stands the extent of retardation has been obtained. The greatest number of untreated seeds germinated on the fourth day from sowing.

Number of days retardation in germination.

Trocadero		Gotte à Forcer		Golden Ball	
Cuprous Oxide ...	5	Cuprous Oxide ...	6	Cuprous Oxide ...	4
Copper Sulphate ...	5	Copper Sulphate ...	–	Copper Sulphate ...	5
Copper Carbonate	–	Copper Carbonate	–	Copper Carbonate	–
Formalin	5	Formalin	5	Formalin	4
Uspulun	1	Uspulun	–	Uspulun	5
Calcium Hypochlorite	–	Calcium Hypochlorite	–	Calcium Hypochlorite	–

Results and conclusions.

(1) Gotte à Forcer is in general more resistant to seed injury than Trocadero or Golden Ball. 50% of Gotte à Forcer seeds treated with mercuric chloride germinated as against 2% of Trocadero and 1% of Golden Ball. Copper sulphate and uspulun at strengths which severely retarded the germination of Golden Ball were innocuous to Gotte à Forcer. Resistance to seed injury in lettuce is a varietal characteristic.

(2) The group of mercury dusts are so toxic that their use for lettuce seed can not be recommended. The strength of mercuric chloride used was too high. Even where uspulun did not reduce the germination percentage a number of seedlings showed the typical symptoms of mercury poisoning.

(3) With the exception of copper carbonate all the treatments were responsible on one variety or another for either a reduction in germination percentage or injury by retardation. The poor adhesiveness of copper carbonate suggests its bactericidal value to be low. Since the concentrations of the dips used were weak (with the exception of mercuric chloride) it is evident that lettuce seed is abnormally sensitive, and successful sterilization presents a more difficult problem than that of sterilizing cereal seed.

(4) Appreciable reduction in the extent of retardation from copper sulphate and uspulun treatments was secured by washing the seed before planting in sterile water.

4. Vegetable Diseases.

H. L. White.

1. Botrytis Rot, Grey Mould, or Wilt of Lettuce.

This disease causes a good deal of damage to lettuce during December and January, especially on cold wet soils and in situations where low light intensities prevail and fogs are common.

The first symptom of the disease is usually the appearance of a water-soaked area near the base of one of the older leaves. Under favourable conditions this area rapidly enlarges, the fungus travels back into the main stem and the plant wilts. The affected leaf and the base of the stem become covered with a grey feathery mould. Sometimes infection commences at the tip of a lower leaf which is reflexed so as to touch the soil. In other cases direct infection of the stem base from the soil occurs. At a later stage the marginal scorch known as "tipburn" provides a starting point for infection which may then spread into the head and in a few days the lettuce becomes unsaleable.

(1) Less than 5% of direct isolations from diseased plants have yielded Botrytis, even where the isolations have been carefully made from the extremities of vascular lesions. The possibility arose that some of the bacteria contaminating these isolations were capable of causing primary lesions. After plating, a selection of different types was used for inoculating the stems of young lettuce plants. Whereas in some cases reddish-tinted water soaked lesions were formed, in no case have these caused the death of a plant as occurs when Botrytis is used.

(2) Three large bolting lettuce, variety Golden Ball, were inoculated by pricking mycelium into the flower stalks at points 14 cms. from the level of the pots. The inoculations were made at 7 p.m., 9/6/33.

At 10 a.m., 12/6/33, the stem of the first lettuce was found to be discoloured, in a streak 1 cm. across, to a distance of 36 cms. above the point of inoculation. All leaves arising from the streaked section of the stem were wilted with their main and sub-veins necrotic. Where leaves originated at the edge of ths streak one half was shrivelled and necrotic and the other was fresh and turgid. The second and third lettuce gave similar results.

An average rate of growth of 0·5 cm. per hour over a period of seventy-two hours would have been necessary for mycelial growth to have accounted for the lesions. Isolations

were made in triplicate from the necrotic tissue and completely sterile tubes were obtained in all cases. It is concluded that the disease in this experiment is primarily a true vascular wilt caused by a toxin liberated by the fungus and carried up in the vascular system of the plant.

The experiment was repeated, using Sclerotinia sclerotiorum isolated from lettuce. Soft sunken "blazes" extended slowly from the points of inoculation and ultimately caused collapse of the seed-stalks. The rapid symptoms of toxicity following Botrytis inoculation were not observed, which suggests fundamental physiological differences between the pathogenicity of Botrytis and that of Sclerotinia.

Progress report on control measures.

(1) The incidence of the disease as contracted from soil infection has been reduced by saturation of the soil surface with 2% Formalin at the rate of 1 gallon per sq. yd. This treatment must be carried out at least ten days prior to planting and a few plants then put in to test if the injurious fumes have left the soil before planting the main crop. Gas masks are a convenience to the workers employed.

(2) Infection of tomato plants by Botrytis in September and October is fairly common. Under the humid conditions frequently prevalent at this time the fungus sporulates abundantly. A crop of winter lettuce is thus exposed to the risk of infection from a heavily contaminated atmosphere under conditions of high humidity and low temperature favourable for infection.

The incidence of the disease under these conditions may be reduced considerably by constant hand-picking of the lower infected leaves before the fungus has time to grow back and infect the main stem.

(3) It is the experience of this Station that a crop of winter lettuce may be grown practically free from infection although abundantly watered. Experiments support the view that it is atmospheric humidity that determines the extent of infection. In watering the hose must be kept clear of the plants, which should not be sprayed at any time during their growth.

2. Bean Wilt.

Material damage has been caused by this disease to autumn-grown glasshouse runner beans. Examination of the stems of affected plants at soil level revealed lesions. In many cases the stem was shrunk and dried and had attempted

to throw out fresh roots above the collar. In others the main root was swollen soft and rotten. Prior to wilting the affected plants were much stunted with small dark leaves and a tendency for the lower leaves to yellow and drop.

Isolations from the diseased stems, which in some cases showed a reddish-brown stain, yielded bacteria. Inoculations of these into germinating beans were inconclusive. On placing affected stems under moist conditions no fungal growth could be observed, but a bacterial rot accompanied by a putrescent odour sometimes associated with *B. carotovorus*. After three weeks several strains of *Fusarium*, sp., appeared on the media of the original isolations, their presence having been obscured previously by bacteria. Further inoculations are in hand.

Whereas several features of this disease are in close agreement with a bean wilt described by Butcher in the Annual Report of this Station for 1924, and ascribed by him to *B. carotovorus*, other features accord rather with the bean wilt caused by *Fusarium*, Martii var phaseoli, and first reported in England by Ogilvie in 1929 (Long Ashton Annual Report).

3. Rhubarb Disease.

Attention has been directed to a serious disease of rhubarb characterised by a dry rot of the vascular systems and apparently hitherto unreported. A number of fungi have been isolated, but further work has been delayed owing to the difficulty of obtaining a healthy stock. Recently a stock of plants apparently free from this disease have been found and it is hoped that the work will be continued. Two hundred plants raised from seed in sterilized soil have been planted in a field so heavily infected that the grower destroyed the rhubarb previously planted and re-planted with another crop. So far the crowns of these plants have remained free from infection.

5. Virus Disease Investigations.

G. C. Ainsworth.

(a) Spotted Wilt of Tomato.

During 1933 ninety-two samples of plants suspected to be suffering from virus diseases were received from growers and examined. Spotted wilt was present in thirty-two cases (tomato 28, cineraria 2, dahlia 1, *Primula malacoides* 1).

The distribution of spotted wilt was wide, being recorded from thirteen English counties, from Wales, and from Ireland (Antrim). Surrey headed the list of counties with five cases, while only two were noted in Hertfordshire.

Outbreaks on large tomato nurseries still appeared rare. mixed nurseries or gardens where tomatoes were not the only crop being most frequently affected. This distribution can be explained by the facts that spotted wilt is able to infect a very large number of different plants and is spread by the agency of the insect thrips, which to transmit the disease must have fed on an infected plant during the larval stage. Thrips do not readily breed on the tomato, but on a mixed nursery they have the opportunity of breeding on other plants, such as cinerarias, which may be infected and from which the adult insects carry the disease to tomatoes.

Control measures against spotted wilt must be directed towards the prevention of infection of the crop which largely depends on the ability of the grower to recognise the disease on different plants, and the control of thrips.

On tomato the characteristic symptoms are a sudden bronzing of the young leaves (usually without stripes on the stem and leaf stalks) and stunting. Among other plants likely to be infected are winter cherry, dahlia, cineraria and chrysanthemum, any of which might carry the disease over from one crop of tomatoes to the next. Notes were given in last year's Report (p. 40) of the symptoms on these plants, but in cases of doubt suspected plants should be sent to the Station for examination.

It is advisable to rogue out infected plants as soon as possible and employ suitable means to destroy thrips (see this Report, Entomological Section). This prevents the disease spreading and special precautions should be taken at the end of the season to insure that no diseased plants or infected insects are left in the houses to re-infect the next crop.

Primula and gloxinia were noted during the year as new hosts of spotted wilt.

Primula sinensis. On the leaves, frequently towards the edges, irregularly-shaped lesions appear which may fuse to give large scorch-like patches. Whole leaves are killed in this way. The veins of the younger leaves yellow slightly and become prominent. The plants are very stunted and no infected plant has flowered. Large lesions develop on leaves mechanically inoculated.

P. malacoides. The symptoms are yellowing of the leaves, which eventually wither, and marked stunting. Necrosis was not observed and no lesions formed on the leaves inoculated.

No infected plant has flowered, death usually resulting. One instance of a severe outbreak on this plant was noted on a commercial nursery where spotted wilt has previously been recorded on cinerarias and winter cherry.

Gloxinia plants were experimentally infected. Large ring-like necrotic lesions developed on the leaves inoculated and some systemic necrosis was observed. Infected plants made no growth and eventually died.

(b) Mosaic diseases of the Cucumber.

The first authentic record of cucumber mosaic in this country is that of Bewley and Buddin* in 1921.

Bewley† recognised two types, which he termed mild or ordinary mosaic and aucuba mosaic. The latter has not been observed during the last three years and at the present time the mild mosaic predominates, while a third type, with a wider host range and considered by Dr. Bewley to be distinct from the "aucuba" form, has appeared.

The mild mosaic and the third type mentioned will be shortly described.

Mild cucumber mosaic.

Disease Synonyms:

Green cucumber mosaic, "cucumber mosaic."

Virus: *cucumber virus 3.*

This is the mosaic of cucumber most frequently recorded at this Station and is the disease generally known here as "cucumber mosaic."

The virus has only been found occurring naturally on cucumber and all attempts to transmit it to plants other than those of the family *Cucurbitaceæ* have failed. The virus can be filtered through Pasteur-Chamberland filters and is resistant to ageing *in vitro* (nine months), heat and chemicals.

Symptoms.

Cucumber, *Cucumis sativus*, is readily infected by mechanical inoculation. Rubbing the leaves with muslin moistened with infected juice results in 100% infection, unless the juice be largely diluted. The most usual symptoms are a dark green mottle together with blistering and distortion of the leaves, also stunting. The symptoms first appear on the younger leaves, and leaves fully developed at the time of inoculation show no symptoms. The mottle is independent of the season but leaf distortion is more marked when the

* Ministry of Agriculture and Fisheries' Miscellaneous Publication No. 38, 51.

† Diseases of Glasshouse Plants, 1923 (Benn, Ltd.).

plant is growing slowly in winter. Yellow flecks often occur on leaves shewing the dark green mottle, and may, on fully developed leaves, attain a diameter of 2—3 cms. and be the most prominent symptom. In experimental inoculations it is usually the two or three leaves developing at the time of inoculation that shew the yellow mottle in the most severe form, while leaves subsequently developed have a green mottle only. In a fruiting plant yellow patches may be a conspicuous symptom on the large lower leaves while young leaves on all the side shoots shew a green mottle only. The results of inoculations from a leaf shewing yellow patches only and from those shewing green mottle only from the apical regions are identical. The fruit may be mottled but is usually unmarked.

Cucumis melo (melon), *C. anguria* (gherkin), and *C. maderaspatanus* have been infected. Symptoms: a dark green mottle of varying intensity, leaf distortion and stunting. *Cucurbita pepo* (vegetable marrow) and *Bryonia dioica* (common bryony) have not been infected and all attempts to infect solanaceous plants have failed.

Yellow cucumber mosaic.

Disease Synonyms.

"Cucumber mosaic," "white pickle" virus.

Virus: *cucumber virus* 1.

This virus has recently been found occurring on cucumber, but it is more frequent on vegetable marrow, and has also been found occurring naturally on tomato, gherkin, *Bryonia alba* (white bryony), *Hyoscyamus*, sp., and *Datura Stramonium*.

The virus has been filtered through Pasteur-Chamberland filters but is not very resistant to ageing *in vitro* (three days), heat and chemicals. It agrees closely, in properties and symptoms on different hosts, with *cucumber virus 1* of Johnson* with which it is considered to be identical.

Symptoms.

Cucumber, *Cucumis sativus*, can be infected at all stages of its growth. Symptoms appear six to ten days after inoculation with young plants, but the period is slightly longer with older plants. The first symptom may be the development of more or less circular yellowish areas on the inoculated leaves, but the characteristic symptoms are a yellow mottle on all the leaves developed after inoculation and stunting. The fruit is usually mottled. Much more severe fruit symptoms are occasionally met with on commercial nurseries when fruits are misshapen, nearly white in colour with irregular green. This condition has not been obtained experimentally.

* Wisconsin Agricultural Experimental Station Research Bulletin No. 76.

The yellow mottle is rather different in colour and type to that produced by *cucumber virus 3*. It is of a greenish yellow colour and on well-developed leaves rather diffuse, the green parts of the leaf yellowing slightly, while the yellow mottle of *cucumber virus 3* is of a greenish cream colour, on older leaves may be nearly white, and much more sharply defined, the background of the leaf remaining dark green.

Vegetable Marrow, *Cucurbita pepo*. A yellow mottle of the leaves with some distortion and stunting. The fruit may be mottled and misshapen but few fruits usually develop.

Tomato, *Lycopersicum esculentum*, is fairly readily infected but there is considerable variation in the symptoms. A very mild mottle without distortion or with slight narrowing of the leaves are the most usual symptoms, but on occasion leaf distortion becomes severe to give the condition known as "fern leaf." A plant exhibiting typical fern leaf has the laminas deeply cut or reduced to such an extent that the leaflets become thread-like (Fig. 3) and in severe cases

Figure 1.—Healthy Tomato Leaf
Figure 2.—Distortion due to Tomato Mosaic
Figure 3.—Distortion due to Cucumber Virus (Fern Leaf)

the petals also are filiform. The occurrence of fern leaf on experimental inoculation (mechanical methods only were used) has been sporadic but independent of the season.

The fern leaf symptom like many symptoms produced by a virus on tomato is not absolutely diagnostic of the virus. Under conditions of high light intensity *cucumber virus 1* is the only agent known to the writer able to produce an infectious fern leaf, but when light intensity is low, as in winter, tomato mosaic virus causes distortion of the foliage

of young plants (Fig. 2) which is liable to be confused with true fern leaf. It is, however, not usually difficult to distinguish the two conditions. If tomato mosaic be the cause the distortion is never so extreme as it can be when due to cucumber mosaic, and if the plant be subjected to better lighting conditions leaves shewing little or no distortion are produced, and finally the plant has a crown of almost normal leaves with a fringe of filiform leaves below. A plant with true fern leaf continues to produce filiform leaves under the improved conditions. The distortion due to tomato mosaic is quite generally known as "fern leaf," but it would be better if this term was reserved for infection with *cucumber virus 1*.

Melon (*C. melo*), gherkin, common bryony (*Bryonia dioica*), tobacco and other solanaceous plants are susceptible to this virus.

Control.

Bewley (Eleventh Annual Report, p. 86) brought forward evidence that cucumber mosaic was transmitted through the seed, and the recommendations for the use of clean seed have proved of great value in reducing the incidence of the disease.

Both mosaics described can be readily spread by juice inoculation, so that eradication or isolation of plants or blocks of plants as soon as symptoms are noticed, together with care in pruning, reduce the rate of spread.

Weeds likely to act as alternate hosts should be destroyed. *Cucumber virus 1* is able to infect solanaceous weeds. The only common cucurbitaceous weed is *Bryonia dioica* (common bryony). It is highly probable that *cucumber virus 1*, at least, occurs naturally on this plant, though the writer has been unsuccessful in transmitting any virus from wild bryony to cucumber by mechanical means in spite of repeated attempts from suspected plants.

Aphids if present should be controlled by fumigation.

Summary.

Two cucumber mosaic viruses of this country are described.

One, which causes a yellow mottle of the leaves, marks the fruit and is transmissible to solanaceous plants, is identified with *cucumber virus 1*, and the other, which is not transmissible to solanaceous plants, does not usually mark the fruit, and typically produces a dark green mottle with blistering and distortion of the leaves, is called *cucumber virus 3*.

Notes are given on "fern leaf" of tomato and control measures.

(c) The effects of manures on tomato plants infected with aucuba mosaic.

Tomato plants (var. E.S.1) in 12-in. pots were inoculated with aucuba mosaic on June 21st when the first truss was in bud. A week later a mottle began to appear on the young leaves and the different manurial treatments were started.

Treatment.

All the plants were top-dressed at the rate of 2 ozs. per square yard every fortnight, or at discretion, with the usual top-dressing (for constitution see Appendix A.). Some plants received in addition dried blood (N), superphosphate (P), or sulphate of potash (K) at the same rate, while cow manure infusion supplemented the top-dressing in one series which had cow manure in place of horse manure in the compost. Five applications of top-dressing were made.

There were five plants in each series. The infected plants were distributed at random in one chamber of the glasshouse and the healthy control plants kept in the two adjacent chambers.

The plants were stopped at the fifth truss and the fruit obtained counted, graded into normal and mottled, and weighed. The trimmings were weighed and the wet weights of the plants after all the fruit had been picked obtained. The first fruit was picked on August 9th and the last on October 10th, when the experiment ended. One control plant became diseased and had to be rejected.

Results.

The result are summarised in Table 1.

There was a marked decrease in size of the infected plants, but the number of fruits set and the total weights of fruit were not significantly different except in the potash and cow manure series where the crops were reduced. It is probable that the healthy plants would have given a good yield on trusses above the fifth while the diseased plants would not.

The healthy control plants averaged 96·3% of clean fruit, while the infected series receiving the normal top-dressing only gave 24·6% of marketable fruit. The percentage of clean fruit from the + N series was double that of the normally top-dressed infected series. Cow manure had no effect but the phosphate and potash series shewed increases of unmarked fruit, though fruit from the potash-treated plants was of small size and included the most severely marked of the whole experiment.

Table 1.

Treatment	Average number of fruits per plant	Average weight of fruit in lbs.	Percentage unmarked fruit	Average weight of plant and trimmings in grams.
Healthy controls	35	2·75	96·3*	726
Infected	—	—	—	—
Top dressing only ...	30·8	2·73	24·6	492
,, + N	32·6	2·86	49·3	424
,, + P	30·0	2·85	43·7	540
,, + K	34·4	1·93	41·7	540
,, + Cow manure ...	30·4	2·33	23·7	476

* 3.7% blossom end rot.

Table 2 shews the distribution of the crop in time. The healthy plants were a phase ahead of the diseased while the effect of the dried blood (N) appeared before that of the phosphate or potash.

Table 2.

	Healthy T.D. only	Infected					
		T.D. only	+ N	+ P	+ K	+ Cow manure	
August 9—31 ...	516	239	281	183	199	227	A
	90·5	0·0	21·8	3·8	8·5	10·3	B
September 1—17	478	686	644	742	416	569	A
	100	33·0	65·4	52·2	44·0	33·8	B
Sept. 18—Oct. 10	248	310	374	366	254	257	A
	100	19·5	37·6	41·7	52·0	14·1	B

A—Weight of fruit in grams. B—Percentage unmarked fruit.

The results suggest that treatment of aucuba mosaic infected tomato plants with a readily available source of nitrogen, such as dried blood, reduces the quantity of mottled fruit.

(d) An experiment with seeds from "streaked" tomato plants.

Seed was collected during August and September, 1932, from glasshouse streak diseased tomato plants and sown in the spring of 1933 in baked soil contained in new boxes at the rate of forty-five per box. Most of the seed was sown in two large batches on March 1st and April 12th respectively. Table 3 summarises the details of the source of seed, number of seeds sown and percentage germination. The percentage germination of the infected seed was significantly less than that of the healthy control seed, 90·3% against 98·3%, but often all the seeds from a diseased fruit were sown while the healthy seed was selected, small seeds being rejected, and this probably accounts for the difference.

Table 3.

Details of source of seed, number sown, and percentage germination.

Variety	Source of Seed	Number seeds sown	Number germinated	
From diseased plants				
E.S.1.	marked fruits	315	305	
,, ...	unmarked fruits	180	146	
,, ... single plant	truss 2, 3 unmarked fruits	90	89	
	3, 7 marked fruits	180	171	
,, ... single plant	truss 3, 1 severely marked fruits	45	45	
	4, 3 ,, ,, ,,	76	57	
Ailsa Craig ... ,,	truss 3, 4 slightly marked fruits	135	109	
,, ... single plant	truss 2, 2 ,, ,, ,,	45	41	
	3, 5 ,, ,, ,,	225	196	
	4, 8 unmarked fruits ...	225	199	
		1,516	1,368	(90·3%)
	Seed from various sources ...		463	
			1,831	
From healthy plants				
E.S.1.	healthy fruit	270	265	(98·3%)
	healthy fruit		80	
			345	

Small random samples were taken of the different batches of seed sown. The samples were bulked, soaked in a little distilled water which was then either used to inoculate tomato seedlings, and the soaked seeds ground up with a further quantity of water, or ground up with the seeds, the mixture being used as inoculation. The presence of virus was demonstrated in the water used to soak infected seed and in crushed infected seed, but not in similarly treated healthy seed.

It is usual for a few seedlings to come up with the seed coats adhering to the expanded cotyledons. Such seed coats were collected from infected and healthy seedlings, ground up with a little water and young tomato plants inoculated. Virus was present in infected seed coats but not in healthy. Table 4 summarises the tests made with seed and seed coats.

Table 4.

Summary of tests for the presence of virus.

	Number of tests		Number position for virus
Whole seed (infected)	6	... ...	6
,, ,, (healthy)	4	... ...	1
Water used to soak infected seed...	2	... ...	2
,, ,, ,, ,, healthy seed ...	2	... ...	0
Seed coats (infected)...	4	... ...	4
,, ,, (healthy)	3	... ...	0
Seedlings (from infected seed) ...	16	(= about 1,200 seedlings)	0
,, (from healthy seed) ...	3	(= about 150 seedlings)	0

One test was made to determine whether virus was present in the embryo as well as the seed coat. Twenty-five infected and twenty-five healthy seeds were crushed with water and virus shewn to be present in the infected but not the healthy. Similar quantities of the seed were at the same time germinated in sterile sand in an incubator. When the seed had germinated the seed coats were carefully separated from the seedlings and after rinsing off adhering sand ground up in distilled water. The corresponding seedlings were also crushed with water. Virus was found to be present in the infected seed coats but absent from the healthy and from all the seedlings.

All the seedlings appeared healthy and developed no abnormality whether from healthy or infected seed. They were grown as long as possible in boxes and finally checked over and discarded about six weeks after sowing, when the seventh or eighth leaf above the cotyledons was developing. Certain plants were transferred to 3½ inch pots and grown on for another month, and when discarded were about 14 inches high with twelve leaves and still quite healthy.

Although a seedling when inoculated on the cotyledons shews symptoms on the first foliage leaf it is possible that plants might be carrying the virus but shewing no symptoms. To test for the presence of "carriers" single leaflets were taken from seedlings, bulked, crushed with a little water and tomato plants heavily inoculated. The number of leaflets taken from one test (*i.e.*, the number of seedlings tested) varied

from twenty-five to one hundred, five to seven tomato plants being inoculated. No carrier was detected in any of the tests (summarised in Table 4). To ascertain the sensitivity of the test one infected leaflet was crushed with one hundred known healthy leaflets and of five tomato plants inoculated four became diseased.

If virus is present on the seed coat it is conceivable that a seedling might become infected if it were injured when withdrawing the cotyledons from the seed coat. By shallow planting more seedlings come up with the seed coats attached to the cotyledons and numbers of seed coats were crushed on the cotyledons with the aid of sterile forceps. About one hundred-and-fifty infected seedlings and a smaller number of healthy were so treated but none shewed signs of disease. The amount of virus on a seed coat must be very small, for in the four tests with infected seed coats noted in Table 4 the numbers of plants infected were four out of ten, one out of five, one out of five, and one out of seven. A one in five infection corresponds to a dilution of between one in ten thousand and one in one hundred thousand as determined by dilution tests.

From the above results it is concluded that in the case of streak the virus is not carried over in the embryo though it is present in the seed coats from which seedlings might be infected. Aucuba mosaic of tomato was taken by Bewley and Corbett (Fifteenth Annual Report, p. 51), who emphasised the importance of the use of clean seed, to differ in this respect, for virus was detected in the embryo and a percentage of the seedlings raised from infected seed became diseased. The recommendation to save seed only from healthy plants holds good for streak as virus is present in the seed coats of seed from diseased plants and only a small number of seedlings need become infected to initiate a serious outbreak, since streak is very readily spread.

6. Physiological Investigations of Mosaic Disease of the Tomato.

W. H. Read.

Considerable differences in the extent and severity of mosaic and other virus diseases may be observed on different nurseries, or indeed on different parts of the same nursery, year after year, even when the variety and source of seed have been similar in each case.

So regular have been these observations that certain areas have been invariably associated with severe symptoms of mosaic disease each year.

Examination of the soil has shewn that the subsoil below these infected areas is almost invariably in a wet and sour condition and it has been assumed that some connection exists between these conditions and the severity of mosaic disease in the crop.

For this reason the relation between chemical and physical properties of the soil and the incidence and severity of mosaic disease is being investigated.

As a preliminary test tomato plants from disease-free seeds (var. E.S.1) were grown side by side in the following soils:—

(*a*) Soil from a nursery in which mosaic disease is particularly severe.

(*b*) Soil (*a*) maintained in a water-logged condition.

(*c*) Soil usually employed for raising plants at the Station.

(*d*) Soil (*c*) excessively manured with horse manure.

(*e*) Soil (*d*) maintained in a water-logged condition.

Symptoms of mosaic disease did not appear in any of these plants and no evidence was obtained that any of these soils are responsible for inducing mosaic disease in clean plants.

A second series of tests were then made in which a duplicate batch was inoculated with aucuba mosaic, and it was found that the symptoms varied in the different soils. Judged by the mottling of the foliage and stunting of the growth, the disease was most severe in series (*b*) and (*e*). Next in severity came (*a*) whilst the symptoms in (*c*) and (*d*) were slight.

Further investigations of this interesting problem are being undertaken.

Experiments were also made in which detached shoots of tomato and tobacco *(Nicotiana tabacum)* were grown in solutions of inorganic salts at concentrations causing marked injury, and also at weaker concentrations which allowed the formation of roots from the base of the stem of the tomato shoots. Inoculation into healthy tomato and tobacco plants of the juice obtained from the damaged tissue of these shoots produced no symptoms of disease in the inoculated plants after eight weeks, and no disease was found after the same period in the plants obtained by potting up the rooted shoots. In addition the same results were obtained in similar tests with substances injurious to plant growth and isolated by other workers from many soils.

Plants were grown in a normal compost to which these substances were added in varying amounts and a parallel series grown in untreated compost, one half of each series being inoculated with aucuba mosaic. On comparing the inoculated plants of each series with the controls it was seen that the effect of aucuba mosaic was increased by the presence of these plant poisons in the early stages. Unfortunately the majority of the control plants became affected with mosaic disease later and thus it will be necessary to repeat this experiment.

In view of the results of this series of tests attempts are being made to isolate from soils where mosaic diseases seriously affect the tomato crop, substances which increase the severity of mosaic when added to normal soils.

The carbohydrate metabolism of healthy and aucuba mosaic tomatoes.

The variations in the carbohydrate metabolism of healthy tomato plants and others infected with aucuba mosaic have been studied by analysis of samples taken at two-hourly periods throughout a period of twenty hours. The plants in the one series were inoculated by rubbing a lower leaf with a crushed leaf from an infected plant and before samples were removed for analysis, six weeks after inoculation, the plants in each series were graded. Any of the inoculated plants with little or no mottling were rejected.

The samples removed for analysis were collected by removing the sixth leaf from twelve plants of each series. The petioles were at once removed, the laminæ and petioles rapidly weighed and placed in boiling 95% alcohol to which a little calcium carbonate had been added. The solutions for analysis were prepared by extraction of the sugars with alcohol, removing the alcohol from a known proportion by evaporation and clearing with lead acetate and sodium phosphate. Reducing sugars were estimated in this by Hagedorn and Jensen's method and total sugars in the same manner after inversion of the non-reducing sugars with hydrochloric acid in the usual way. Starch was estimated in the dried residue from the alcohol extraction by hydrolysis with taka-diastase under standardised conditions and estimation of the sugar so formed.

The results obtained suggest that in the laminæ of plants infected with aucuba mosaic there is a time lag in the conversion of reducing sugars into non-reducing sugars. In the healthy laminæ the concentration of reducing sugars remained almost constant throughout the period of the

experiment whilst the concentration of non-reducing sugars rose during the day to a maximum at 3 p.m. In the diseased laminæ the amount of reducing sugars rose to a maximum at 3 p.m. and then fell rapidly whilst the concentration of non-reducing sugars began to increase at noon and did not reach a maximum until 6 p.m. The mean concentration of reducing sugars in the healthy and diseased laminæ shewed little difference, but the amount of non-reducing sugars was considerably greater in the healthy laminæ. The starch values shewed little difference apart from slightly greater amounts in the diseased laminæ. This similarity in the starch metabolisms was contrary to expectation for previous results had shewn in either case very marked differences in amounts and the daily fluctuations of the amount. The values obtained from an examination of the petioles shewed that in healthy plants reducing sugars were present in greater amounts than non-reducing sugars, the latter shewing little variation throughout, while the amount of reducing sugars rose to a maximum at 6 p.m. and fell to a minimum at 2 a.m. In the diseased petioles reducing and non-reducing sugars were approximately equal in amount between 8 a.m. and 7 p.m., shewing the same maxima at noon and 6 p.m. After this time the amount of non-reducing sugar fell rapidly to a very low value.

7. Leaf Mould of Tomatoes.

O. B. Orchard and W. H. Read.

(a) Control by vaporisation of sulphur.

During the past season an improved type of sulphur vaporiser was tested as a means of controlling leaf mould. The principle of this machine is the emission of sulphur vapour mixed with steam, which prevents the ignition of the sulphur. The experiments were conducted in a house 100 feet long by 15 feet wide.

The vaporiser was not available until the first week in June, at which time leaf mould was already in evidence. Previous experiments have shewn that to be effective a thin film of sulphur must cover the foliage. Sulphur was vaporised at weekly intervals using ½ lb. sulphur per house, this quantity being sufficient to leave a faint yellow deposit on the foliage. The treatment was continued over a period of six weeks. By comparison with other control measures employed on the nursery the attack of leaf mould was less severe in this house. It was noticed, however, that this treatment caused a marked yellowing of the foliage, and slight scorching of open flowers.

During the coming season experiments will be continued with this vaporiser, using it before leaf mould appears on the plants, with the object of testing the vaporisation of sulphur as a preventative.

(b) Fumigation with Quinone.

Small (Sixteenth Annual Report, p. 43) shewed that pure quinone was effective when used as a fumigant against tomato leaf mould. A sample of crude quinone kindly supplied by Imperial Chemical Industries, Ltd., was tested during the past season. When used at ½ oz. per thousand cubic feet the spores of the fungus were killed, but the foliage was scorched. This scorching was very much more pronounced in some parts of the house than in others, and is attributed to uneven distribution of the vapours, for owing to the low volatility of quinone at ordinary temperatures, the vapour from the vaporisation vessel immediately condensed in the form of minute crystals.

3. Entomological Investigations.

1. The Red Spider Mite.

E. R. Speyer.

Certain spray-fluids purporting to contain rotenone were tested with a view to the possible control of the Red Spider Mite (*Tetranychus telarius*, L.).

On May 19th arum pot plants heavily infested with adult mites, and tomato pot plants infested with the mite in various stages, were sprayed thoroughly with ½ fluid ounce concentrate to 1 gallon water.

After twenty-four hours about 1% of the adults remained alive upon the arum foliage. After forty-eight hours a well infested tomato shoot shewed three male, twelve female, seven protonymph and ten larvæ to be dead; five females and nineteen larvæ were alive. Larval resting stages moulted and eggs hatched on the following day.

On the fifth day after spraying the following mites were collected from three well sprayed leaves: Dead—eight females, four deutonymphs, sixteen larvæ; alive—six females twenty-five larvæ.

Seven larvæ and one protonymph resting stage were collected from these leaves, of which the latter and five of the former moulted on the following day.

Twelve days after spraying numbers of living males and females and deutonymph resting stages were present upon the tomato plants.

On June 13th infested plants in a tomato house were thoroughly sprayed with 7 fluid ounces concentrate to 12 gallons water. After twenty-four hours the following mites were collected from well sprayed foliage: Dead—twenty-one females, six males, nine deutonymphs, nine protonymphs, fourteen larvæ; moribund—eight females, one protonymph, two larvæ; alive—two females, one male, one deutonymph, twenty-nine larvæ.

The following were set aside for further observation:—Ten deutonymph resting stages, five protonymph resting stages, twelve larval resting stages, and fifteen eggs. One deutonymph moulted on the following day, but no further moults occurred and none of the eggs hatched during the ensuing seven days. Some of the moribund females were still alive at the end of this period, and had deposited eggs.

On June 23rd a considerable number of mites were alive upon the sprayed foliage, and a migration of mites had taken place to new foliage put out, this being severely infested.

On July 19th some tomato shoots infested with mites were sprayed with an emulsion composed of rotenone ·12%, acetone 5% and saponin ·1%.

After twenty-four hours all the mites appeared dead, except one larva, probably hatched after spraying.

After forty-eight hours the following mites were collected: Dead—five females, many young stages; moribund—three females; alive—one female, 12 larvæ.

Five days after spraying many mites were alive and had migrated to the upper surface of the foliage.

A control spraying with a similar concentration of acetone, but without rotenone, appeared to drive the mites to the upper surface of the foliage; a few adult mites appeared to be killed. Although in the course of these experiments sprays containing rotenone appeared sometimes to kill some of the eggs and resting stages, they were always very uncertain in their action, and a reasonably good control on commercial nurseries is certainly not to be expected from sprays containing this substance.

Unless a spray-fluid contains an ingredient which is definitely ovicidal in action, or retains its toxic properties for at least four days upon the leaf-surface, no practical control of the mite is to be expected. During the summer months at least 50% of the mites occurring upon tomato foliage are in the egg stage, which lasts over a period of some six days.

Some experiments, on a small scale, were carried out with a dust containing methyl salycilate*. Young foliage of the tomato plant proved highly susceptible to the vapour liberated by the powder, but as a certain proportion of mites were killed further experiments will be carried out in the future.

Owing to reports of successful control of a mite affecting the strawberry plant by hot-water treatment, experiments were carried out upon Red Spider Mite with a view to determining at what temperature the mite could be killed. Shoots of tomato infected with the mite were placed in an incubator in which the temperature was varied from 113°F. (45°C.) to 122°F. (50°C.).

*Kindly prepared and supplied by Messrs. Allen and Hanbury's, Ltd.

When the atmosphere was saturated death of the mites ensued at 120°F. in a period of two hours, but with a drier atmosphere the mites only began to succumb after an exposure of five hours at 122°F. (50°C.).

Mites upon infested tomato pot plants kept in a closed chamber of 100 cubic feet during a hot sunny day in August with a saturated atmosphere were not killed. It would, therefore, appear that in practice the mite cannot be controlled in tomato houses by maintaining a high temperature and a saturated atmosphere.

Since it was first observed in October, 1925, a Cecidomyid midge, *Therodiplosis persicæ*, Kieff., the grubs of which feed upon the Red Spider Mite, has annually become more prevalent, and made its appearance earlier in the season in the Lea Valley. It is suspected that this midge has sometimes exerted a definite control upon the pest, not only in tomato houses, but upon peach trees grown under glass in the Worthing district. Efforts are now being made to find out how this insect passes the winter, and to find, if possible, a means of increasing its numbers, upon commercial nurseries.

As yet it has never been found in cucumber houses.

2. Tomato-moth Caterpillar.

Through the increasing growth of catch-crops in tomato houses, it is important that a non-arsenical substance be substituted for lead arsenate as a spray for the control of the tomato-moth caterpillar (*Polia oleracea*, L.).

Experiments have been continued with the double fluoride of aluminium and sodium known as cryolite.

Hitherto, the chief difficulty in applying this substance lay in the problem of its adhesion to foliage. This difficulty has largely been overcome by adding rape oil to a finely-divided and light form of synthetic cryolite, but the method is not applicable either to the natural mineral or to all forms of the synthetic compound. In the best formula obtained 4 fluid ounces of water were stirred into ½ lb. synthetic cryolite (guaranteed to pass a two hundred mesh sieve) and 2 fluid ounces of rape oil gradually added to this. The resultant creamy paste has been kept without deterioration for six months. When stirred well with a little water the stock paste is readily liquified for adding to the bulk of water in the spraying tank.

An agitator in the latter is essential as the cryolite particles will not remain for more than a few minutes in suspension even upon the addition of comparatively large quantities of saponin. During May ninety tomato plants in the ground were sprayed with various mixtures containing cryolite, caterpillars being placed from time to time upon them. Though no spraying was carried out during June only one or two caterpillars were found upon the plants at the beginning of July. Fresh caterpillars were now introduced, aad all the plants were sprayed with the formula given above, using 2 ounces stock to 1 gallon water. During the month the yield was over 1 lb. per plant of good fruit, and no scorching of foliage occurred at any time. At the beginning of August less than 1% of the fruit shewed feeding marks of the caterpillar, and the foliage had hardly been eaten at all. After pickings it was found necessary to remove the cryolite deposit upon the fruit by gentle wiping with a cloth.

From many observations made upon caterpillars to which sprayed foliage was fed it became evident that cryolite makes this distasteful to them, and only acts as a poison if the caterpillars are very hungry and thus take in enough upon their food to cause death. As is largely the case with lead arsenate, the majority of caterpillars find the sprayed foliage distasteful and eventually die of starvation.

Although not technically considered to be poisonous to man it would probably be undesirable to spray tomato plants under which lettuce is growing unless the latter were well washed before marketing. Spraying with cryolite is rather intended as a check upon the caterpillar later in the growing season, at a time when lead arsenate definitely cannot be made use of.

A colloidal form of cryolite has recently been obtained, and experiments with it will be carried out in the coming season.

3. Parasites of the Tomato-moth.

On July 19th a chalcid parasite of the tomato-moth caterpillar made its appearance in the Experimental Station tomato houses. This has been identified by Dr. L. Ferriere as *Comedo opaculus*, Thoms., and is allied to or identical with a parasite found in France upon the same host in 1930. The life-history of the parasite was observed in detail and three generations were bred up to the beginning of November, when the majority of parasites were found to hibernate as chrysalids, surrounding the dead caterpillars upon which the

eggs had been laid externally. Several factors in the habits of the parasite make it doubtful if this insect will be of any economic value in the control of its host. They are:—

(1) The preponderance of males toward the end of the growing season, when the caterpillars are most numerous.

(2) The fact that one female parasite lays all its eggs on one caterpillar, and often several parasites select the same caterpillar for oviposition.

(4) Eggs are laid practically only upon caterpillars of large size, after the fourth or fifth moults of the latter, and then only at a time shortly after one of those moults.

(4) Other caterpillars, namely, those of the cabbage moth (*Mamestra brassicæ*, L.), and of the angle-shades moth (*Phlogophora meticulosa*, L.), serve as hosts for the parasite; both these caterpillars occur in or near glasshouses, so that parasitism is not concentrated upon one host.

Hopes were entertained that this insect might be bred through the winter upon the angle-shades caterpillar, which is a pest of the chrysanthemum plant, but caterpillars upon which eggs were laid in December cast these off with their moulted skin, and pupated normally.

In the early part of the year, however, it still remains to be seen if the habits of the parasite may not be different.

Parasitised caterpillars may be recognised by the presence upon them of green or pink sausage-shaped grubs which cling to them between the dorsal segments or protude from folds of skin at the sides just above the leg-bases. More frequently, however, the parasite is to be met with in its chrysalis stage, which is coal black, and numerous chrysalids are stuck tightly to the surface of a leaf or stem, or upon a supporting string, in close proximity to the dead caterpillar.

Observations upon the common ichneumon wasp (*Pimpla instigator*, L.), which parasitises the chrysalids of the tomato moth to the extent of about 25% of the latter, have as yet thrown no light upon the manner in which the egg is deposited within the chrysalis. About fifty adult parasites emerged from two hundred chrysalids collected at random from tomato houses in October, and these were kept alive until December 8th, upon which date all died for an unknown reason. It is probable that the prolonged warm weather caused an unnatural emergence of adults, and that normally the parasite hibernates as a larva or pupa within the tomato-moth chrysalis.

It is possible that means will be found for increasing the numbers of the parasite, which may then become of considerable value in checking this pest.

4. Thrips.

The Onion Thrips, *Thrips tabaci*, Lind., has become a pest of considerable importance to the tomato grower. Although the insect seldom breeds upon tomato plants unless they are grown under very unfavourable conditions, it is liable, in the adult stages, to gain access to the houses from outside, where its larvæ may have been feeding upon certain weeds or cultivated plants infected with the virus disease known as "spotted wilt."

By feeding lightly, as it often does, upon the young foliage of tomato plants, they may thus transmit this serious disease. The adult Thrip hibernates in the ground, and will from time to time obtain nourishment from the foliage of tomato pot-plants, and from young plants in the ground very early in the season.

This Thrips is an habitual pest of the cucumber and cinerarea plant, and causes much injury to the flowers of Carnation, Cyclamen, and Arum.

Experiments with dusts containing nicotine, naphthalene, and lime, for the control of the insect upon Arum flowers shewed that the flowers were liable to injury from the lime. Prof. H. Armstrong suggested that the lime should be replaced by magnesium hydrate, and promising results in the control of the Thrips has been obtained by dusting Arum and Cyclamen plants with a powder made up of naphthalene and magnesium hydrate in equal proportions, with a 4% nicotine content. A considerable quantity of the powder was most generously supplied by Messrs. Allen and Hanbury's. Applied to carnation plants, upon a nursery in the Worthing district, however, the dust was ineffective, doubtless owing to the difficulty of reaching the insects in their concealed position within the flowers.

Where there is suspicion of the presence of the Onion Thrips in tomato houses, it is recommended that the soil be steamed during the winter, and that weeds be cleared from the vicinity of the houses; further that the growing of cinerarea, dahlia, nasturtium, potato, or onion plants near tomato houses be in all cases strictly avoided.

Owing to the difficulty in persuading growers to carry out experiments upon their nurseries, no progress has been made in the control of the Rose Thrips (*Thrips fuscipennis*, Hal.). A portion of a cucumber house infested with this insect was, however, dusted with the powder mentioned above, but the

treatment was without effect upon insects or plants. Research upon the control of an allied species of Thrips, which is a pest of fruit blossom in Australia, has shewn Pyrethrum dust to afford the best means of control, and experiments will be carried out with this insecticide in glasshouses in the near future.

It has been observed that the buttercup flower appears to be the chief out-door host of the Rose Thrips.

Owing to the importance to the economic entomologist of obtaining correct identifications of destructive species of Thrips, a paper has been published in the Annals of Applied Biology in which new and constant diagnostic characters for recognition of the common British species of this genus, are elucidated.

5. Millepedes.

A common Milleped, *Blanjulus guttulatus*, Bosc. often occurs in undesirable numbers in the soil of tomato houses, and in that of the pots of Chrysanthemum plants.

Experiments have been carried out with a view to finding out how much naphthalene it is necessary to mix with soil in order to kill the Millepedes.

Flake naphthalene mixed with soil at the rate of one part to five hundred parts soil by weight gave 100% mortality by the 4th day after mixing, but fresh millepedes placed in the soil after this period of time had elapsed were unaffected. With half the quantity of naphthalene a complete mortality was not obtained.

Distributed upon the soil surface and well watered in at the rate of 4 ozs. of naphthalene per square yard, all the millepedes were killed to a depth of 3 inches, but from 3 to 5 inches below the surface, only 50% were found to be dead after a period of four days.

On commercial nurseries it is estimated that not less than 6 ounces of naphthalene per square yard would be required to be dug into the soil in order materially to reduce the numbers of these animals, and probably 8 ounces would be necessary on heavy soils.

6. Investigations of the Control of Wireworms

O. B. Orchard.

During the course of advisory work, experiments were conducted on certain nurseries with regard to the control of wireworms. The usual practice of trapping the pest in tomato houses with carrots and other baits entails much labour by continual examination of the traps, and trials have been made with poisoned baits which could be placed in the soil before planting the tomatoes and then left alone.

For this purpose such substances as will attract wireworms, and will remain in the soil some time without decomposing were used. In view of previous experiments, wheat and potatoes were chosen as the attractive baits. These were impregnated with solutions containing various amounts of the following substances:—sodium fluoride, sodium arsenate, sodium arsenite, barium chloride, nicotine and oxalic acid.

These baits were placed in boxes of soil containing a known number of wireworms, but in no case did the wireworms feed on the poisoned material. The experiments are being continued.

Control of millepedes.

During the past season, millepedes caused extensive damage to roots and stems of cucumbers. In view of the seriousness of this damage, a number of substances were tried on commercial nurseries severely infested with the pest to determine the most satisfactory method of control.

A number of substances in solution were used to soak the beds and borders, and of these, emulsified pyridine bases proved satisfactory, but owing to the work involved in measuring small quantities of the insecticides, and of applying large quantities of the diluted solutions to the beds, this form of control was abandoned.

Further experiments were conducted in which the beds were dusted with substances which gave off vapours destructive to millepedes. Naphthalene proved to be the only substance which will kill the millepedes without injuring the plants. Para-dichlorobenzene gave good control of the pest, but cannot be recommended owing to slight scorching of the foliage.

During the early part of the season, Grade 16 naphthalene should be used, but towards the end of the season whizzed naphthalene may be employed with safety, as the older foliage is less liable to scorch. The naphthalene should be broadcast over the beds and borders using 24 ounces per 100 ft. run of bed. This treatment should be applied towards the end of the day, and be continued at weekly intervals while the pest is in

evidence. Careful distribution of the naphthalene is essential as it is not advisable to dust the powder on the stems of the plants. It should be scattered over the entire surface of the beds and borders paying particular attention to the cracks between the soil and the walls, as these are favourite hiding places for millepedes.

7. A combined Fungicide and Insecticide for use in controlling Tomato Leaf Mould and the Red Spider Mite.

O. B. Orchard.

It is well known that tomato leaf mould and the red spider mite frequently occur on the same crop throughout the season. The most satisfactory fungicide employed in controlling leaf mould is Shirlan paste and Agral N. as described in the Seventeenth Annual Report, 1931, page 39, whilst oil emulsions form the basis of most insecticides in use for the control of the spider mite.

Recent investigations have shewn in many cases that if crops previously sprayed with Shirlan Paste and Agral N. are sprayed with oil emulsions, slight scorching of the foliage occurs. To avoid this difficulty a period of ten days should elapse between the two applications. This can be managed easily when the attack of disease and pest is not severe, but considerable difficulty in effecting a control is experienced in cases of severe infection.

In view of this difficulty, experiments have been conducted during the past season with a colloidal copper compound mixed with an oil emulsion. This mixture does not cause scorching of the foliage or damage plants in any way, and gives good control of both leaf mould and the spider mite without the necessity of using separate sprays.

The estimation of copper on leaves sprayed with the colloidal copper compounds, used in the one case with Agral or Lethalate as the spreading agent, and in the other case mixed with an emulsified petroleum, shewed that the amount of copper retained on the foliage is greater when the oil mixture is employed, and is thus more effective as a fungicide.

The following mixture is recommended when leaf mould and red spider attack the same crop:—oil emulsion mixed at the rate of 1 gallon to 100 gallons of water, to which half-an-ounce of colloidal copper is added for each gallon of the diluted emulsion.

This spray mixture gives equally good control of mildew and red spider mite on cucumbers.

3. Chemical Investigations.

1. Nitrates in Tomato Soil.

O. Owen.

In some pot experiments the effect of excess nitrate on the nitrate status of soil was examined. It was found that where nitrates (in the form of potassium nitrate solution) were added the nett increase in nitrate concentration was considerably in excess of that in similar untreated soil and in similar soil treated with an equal volume of water. On the basis that denitrification tends to occur under all conditions this result is taken to mean that excess of nitrate depresses the activity of the factor responsible for denitrification. On the other hand it may mean that excess of nitrate increases nitrification.

The nitrates in a plot in which the soil was heated and the nitrates in unheated soil are shewn in Table 1.

Table 1.

Date	Unheated		Heated	
	Nitrate —N p.p.m.	% Water	Nitrate —N p.p.m.	% Water
May 1	80·11	22·96	115·7	22·16
,, 8	121·4	23·71	112·0	23·20
,, 8	Both plots watered			
,, 15	74·18	24·14	37·39	21·67
,, 16	Both plots top-dressed and watered			
,, 22	137·6	23·61	53·89	21·01
,, 23	Both plots watered			
,, 29	59·98	22·61	35·98	20·78

It will be noticed that at each sampling the water content of the heated soil is lower than that in the unheated soil. Except on May 1st the nitrate concentration was lower in the heated than in the unheated soil. This may mean one or both of two possibilities. These are:—That nitrification is actually less in the heated soil or that the plants in the heated soil assimilate nitrates more quickly than do those in the unheated soil.

Having regard to the beneficial results following the incorporation of spent hops in tomato soil it was considered worth while determining the nitrate concentration in such a plot. The results were compared with those in the control plot and a plot to which peat had been added. They are given in Table 2.

Table 2.

Date	Peat added		Spent Hops added		Control	
	Nitrate —N p.p.m.	% Water	Nitrate —N p.p.m.	% Water	Nitrate —N p.p.m.	% H_2O
May 3 ...	103·9	22·14	259·9	25·22	162·9	19·80
,, 11 ...	All plots watered					
,, 12 ...	94·19	22·98	226·9	27·41	41·62	21·32
,, 16 ...	All plots top-dressed and watered					
,, 18 ...	69·39	23·23	135·2	26·29	129·3	22·01
,, 23 ...	101·0	21·43	206·5	23·04	122·9	18·35
,, 23 ...	All plots watered—after sampling					
,, 30 ...	86·54	20·15	163·6	21·91	88·8	18·31

At each sampling the water and nitrate contents of the soil containing spent hops are higher than those of the other two plots and one or both of these facts may explain, in part at all events, the beneficial effect of spent hops on the tomato crop.

2. The Potash in Drainage from Tomato Houses.

The potash contents of samples of drainage, from the drained plot, during 1931 and 1932 are reported in Tables 3 and 4 respectively. In 1931, the plot was cropped and manured; in 1932, it was fallow and unmanured. As was the case with nitrogen in the drainage for these two years, the loss of potash was higher when the bed was fallow and unmanured.

Table 3.

1931.

Date	Volume in litres	Concentration gms. K_2O per litre	Total K_2O gms.
May 5	64·89	·3570	23·16
„ 18	41·18	·2852	11·74
„ 20	20·3	·2889	5·865
„ 23	55·11	·3646	20·04
„ 27	34·8	·3528	12·27
June 1	159·5	·1696	27·06
„ 5	55·11	·1639	9·033
„ 9	75·41	·1724	13·00
„ 12	78·3	·1843	14·43
„ 18	46·4	·1771	8·217
„ 22	31·9	·1989	6·345
„ 26	78·3	·1398	10·95
„ 29	81·2	·1040	8·448
July 3	87·06	·1421	12·37
„ 6	64·39	·2397	15·44
„ 10	104·4	·1057	11·04
„ 15	142·1	·1217	17·30
„ 23	81·2	·1370	11·12
Aug. 8	46·4	·1270	5·891
„ 15	116·0	·1336	15·50
Sept. 12	23·2	·1465	3·399
„ 19	40·6	·1268	5·147
		Total	268

The total potash lost in 1931 corresponds to 583 lbs. of sulphate of potash per acre, and in 1932 to 625 lbs. per acre, making a total of 1,208 lbs. per acre. During the same period the loss of nitrogen in the drainage from the same plot corresponded to 940 lbs. of sulphate of ammonia per acre. As we have been somewhat concerned during recent years with nitrogen losses, it is noteworthy that on a strict cash basis considerably more is lost in the drainage as potash than as nitrogen. It is believed by many nurserymen that potash losses are negligible under glass. The figures now given shew the fallacy of such beliefs. The probability is that the lime

added to nursery soils tends to wash potash out and th is is a further argument in support of the view already expressed in these reports, that lime dressings should be reduced, and in some cases omitted.

Table 4.

1932.

Date	Volume in litres	Concentration gms. K_2O per litre	Total K_2O gms.
May 19 ...	53·65 ...	·1924 ...	10·32
„ 25 ...	84·1 ...	·2172 ...	18·27
June 1 ...	47·85 ...	·2081 ...	9·956
„ 8 ...	33·36 ...	·2811 ...	9·380
„ 15 ...	81·21 ...	·2850 ...	23·15
„ 17 ...	100·1 ...	·2043 ...	20·45
„ 22 ...	119·0 ...	·1910 ...	22·73
„ 29 ...	102·9 ...	·1874 ...	19·28
July 6 ...	116·0 ...	·2066 ...	23·97
„ 13 ...	121·8 ...	·2043 ...	24·88
„ 20 ...	116·0 ...	·1706 ...	19·80
„ 27 ...	100·1 ...	·1594 ...	15·96
Aug. 10 ...	116·0 ...	·1526 ...	17·70
„ 18 ...	81·21 ...	·1686 ...	13·70
„ 25 ...	101·5 ...	·1445 ...	14·67
Sept. 6 ...	111·6 ...	·1363 ...	15·21
„ 21 ...	58·01 ...	·1360 ...	7·889
		Total	287

3. The Effect of Manurial Treatment on the Nitrogen Contents of some Market Garden Crops.

When it was decided to discontinue some of the tomato manurial trials a few years ago, the soils from the plots were transferred to concrete pits at the south end of the tomato block. As each soil had received the same treatment repeatedly for a number of years, it was considered of interest to grow some crops of commercial importance and to determine the effect of the manurial treatment on them. Also, in view of

the interesting results already recorded of the analysis of tomato foliage produced under different manurial conditions, it was decided to harvest the crops and analyse them. The plants were sown and grown in the ordinary way and consisted of beet, carrots, runner beans, and cabbage. They received no manurial treatments during the growing period. It may be stated that at no stage during this period were there any differences in the appearance of the plants to suggest that they were growing in anything but the same soil throughout. Chrysanthemums were grown in pots filled with the different soils and these were grown with the main chrysanthemum crop at the Station with the difference that they were fed differently. Plants in unmanured soil remained unmanured, those in the "complete artificial" soil received a "complete" chrysanthemum fertiliser, and those in the other soils were dressed with chrysanthemum fertiliser from which was omitted nitrogen, phosphates and potash respectively.

So far only the nitrogen estimations have been completed. These, together with the green and dry weight are given in Table 5 for the chrysanthemums, and in Table 6 for the other plants.

It will be seen from Table 5 that both weights produced and nitrogen contents of chrysanthemums are highest with complete artificials and dung, and lowest in the soil from which potash has been omitted.

Table 5.

Chrysanthemums (Cheshunt White) average of 12 plants.

Treatment	Weight per plant excluding roots gm.		Nitrogen		
	Green	Dry	% in dry matter	% in Green matter	Total N. per plant gm.
Unmanured	61·0	12·08	1·4803	·4645	·2834
Complete artificials and dung	93·25	18·91	2·2150	·4493	·4190
Complete artificials ...	79·17	15·00	2·034	·3853	·3051
Phosphates omitted ...	68·75	13·83	2·0405	·4101	·2821
Nitrogen omitted	68·25	11·75	2·5585	·4405	·3007
Potash omitted	54·17	9·30	2·1385	·2916	·1989

It is noteworthy that in the soil from which nitrogen has been omitted the nitrogen is almost as high as that in soil dressed with complete artificials.

Table 6.

Crop	Treatment	Total Weight Gm.		Nitrogen		
		Green	Dry	% in Green matter	% in Dry matter	Total Gm.
Carrot Foliage	Complete artificials ...	425	75	·4670	2·646	1·985
	Phosphates omitted ...	802	119	·4157	2·795	3·326
	Nitrogen omitted ...	760	104	·3510	2·565	2·668
	Potash omitted	850	112	·3263	2·4705	2·773
Carrot Roots	Complete artificials ...	690	76	·1673	1·519	1·157
	Phosphates omitted ...	807	77	·1108	1·1605	·8937
	Nitrogen omitted ...	774	80	·1179	1·140	·9120
	Potash omitted	894	88	·1562	1·5855	1·396
Beet Foliage	Complete artificials ...	658	62	·3116	3·307	2·050
	Phosphates omitted ...	669	56	·2597	3·103	1·730
	Nitrogen omitted ...	522	52	·2744	2·755	1·433
	Potash omitted	732	72	·2879	2·9275	2·108
Beet Roots	Complete artificials ...	1296	127	·2973	3·035	3·854
	Phosphates omitted ...	1130	135	·2904	2·431	3·282
	Nitrogen omitted ...	856	114	·2555	1·919	2·187
	Potash omitted	912	113	·3195	2·578	2·914
Bean Pods	Complete artificials ...	880	84	·2661	2·7875	2·342
	Phosphates omitted ...	720	124	·4245	2·465	3·056
	Nitrogen omitted ...	524	57	·2955	2·7165	1·548
	Potash omitted	660	85	·3578	2·7775	2·361
Bean Foliage	Complete artificials ...	1000	170	·4757	2·779	4·757
	Phosphates omitted ...	1270	226	·4086	2·296	5·189
	Nitrogen omitted ...	969	115	·3220	2·7125	3·120
	Potash omitted	859	150	·4897	2·8035	4·207
Cabbage* Foliage	Complete artificials ...	877	78·5	·3228	3·607	2·831
	Phosphates omitted ...	736	75·5	·3072	2·990	2·258
	Nitrogen omitted ...	863·5	81	·3022	3·222	2·610
	Potash omitted	861·5	75	·3293	3·781	2·836

* Average of six plants.

Table 6 shews:—

(*a*) Omission of phosphates increases nitrogen contents of carrot foliage, bean pods and foliage, and depresses the nitrogen in carrot roots, beet foliage and roots, and cabbage.

(*b*) Omission of nitrogen depresses the nitrogen content of all samples except carrot foliage.

(*c*) Omission of potash increases nitrogen content of carrot roots and foliage, and depresses the nitrogen in beet roots, and bean foliage. It has little effect on cabbage foliage, bean pods, and beet foliage.

5. Physiological Investigations.

1. The influence of Light and Temperature on the Assimilation Rate of Seedling Tomato Plants, Variety E.S.1.

B. D. Bolas.

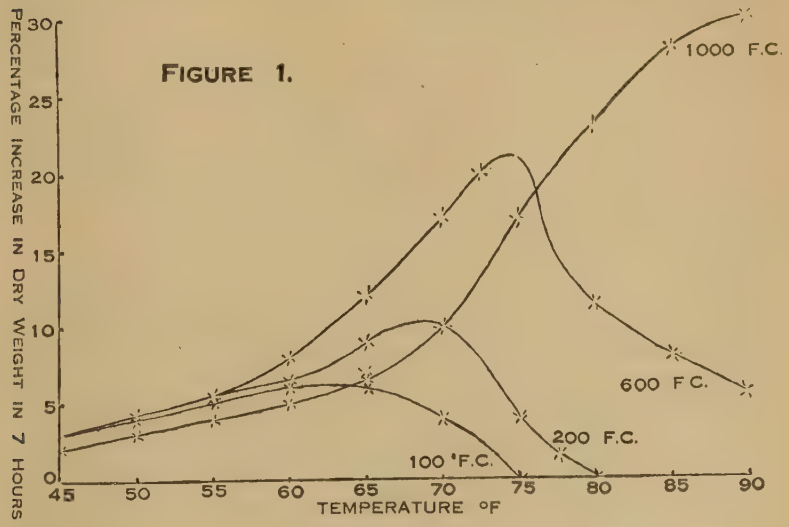
The assimilation rate of a green plant may be defined briefly as the rate at which unit weight of the plant takes carbon dioxide from the surrounding air and converts it into plant material. A convenient measure of assimilation rate is obtained by determining the percentage increase in the dry weight of the plant during any suitable period of time. Such a measure like all other direct measures of assimilation rate gives what is sometimes known as the "apparent" assimilation rate owing to the fact that even during carbon assimilation a part of the carbon is lost by the respiration of the plant.

In the work carried out during the past three years on the influence of light and temperature on seedling tomato plants, all determinations of assimilation rate have been on a basis of the "apparent" value over an assimilation period of seven hours, and the method used has been one of which a full account has been published elsewhere. The work has been confined to seedling plants of the variety E.S.1, about 5 inches high.

It is generally considered that practically the whole of the energy required by the green plant in building up complex organic substances from carbon dioxide, water and inorganic salts is obtained from the light which falls upon it, hence it is obvious that for a given leaf area there is, at least for practical purposes, a maximum assimilation rate for any particular light intensity, and that the assimilation rate cannot rise beyond this as a result of any alteration in temperature, water, manuring or any other cultural condition. It may well happen on the other hand that the conditions, such as temperature, do not enable the plant to take full advantage of the incident light. Thus a considerable amount of the light, a factor that is undesirably low during the winter months, may be wasted. It is with a view to obtaining a better understanding of these and similar problems that the present work was undertaken.

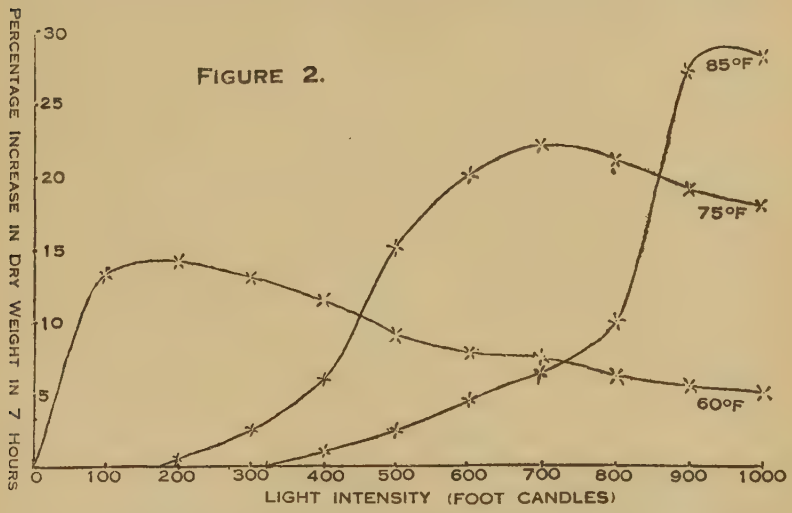
In Figure 1 the effect of temperature is shewn for various light intensities. The curve marked 100 f.c. shews the case of a plant growing under a mean light intensity of 100 foot

candles, that is to say under the conditions obtaining in a clean glasshouse on a rather dull winter day, and it will be seen that the assimilation rate rises with temperature from 45°F. to about 62°F., but that any increase in temperature beyond this results in a rapid falling off in assimilation rate and is very definitely harmful rather than good. The curve marked 200 f.c. corresponds to the conditions on a bright winter day, and the assimilation rate will now rise with temperature up to about 68°F., but the falling off when this temperature is exceeded is even more rapid. The curve marked 600 f.c. represents a really bright day in spring, and the temperature at which assimilation rate is at a maximum is now about 75°F., while on a bright summer day as shewn by the curve marked



1000 f.c., a temperature of 90°F. is not excessive *from the point of view of assimilation rate.* It does not follow, however, that a temperature of 90°F. is the best at which to grow the plants owing to the fact that a number of the so-called secondary effects of temperature such as injury to the protoplasm of the cells, disturbance of the water relations of the leaf and change in the distribution of assimilate to various parts of the plant may shew themselves if a high temperature is maintained for a long period. Nevertheless, the curves in this figure shew with surprising clearness that for any particular light intensity there is one temperature and one temperature only at which the assimilatory mechanism of the plant is working most efficiently.

Figure 2 shews the effect of different light intensities on plants grown at various temperatures and emphasised the fact that just as we may have the wrong temperature for any particular light intensity so we may have the wrong light intensity for any particular temperature. Thus, if one examines the curve marked 60°F., it is clear that with increasing light intensity from 0 to about 100 foot candles there is a rapid rise in the assimilation rate, but that beyond this point an increase in light intensity fails to produce any further rise in assimilation rate, and that as the light intensity is still more increased there is a marked fall in assimilation rate, and that in order to



increase this rate it is a rise in temperature that is required. The remaining two curves in Figure 2 shew clearly how the best light intensity depends on temperature.

It will be observed that owing to variation of the plant material and other factors that the curves in Figure 1 and in Figure 2 do not agree perfectly as to the relation between light and temperature necessary to obtain the highest assimilation rate, thus Figure 1 shews a temperature of 63°F. as giving the highest assimilation rate at a light intensity of 100 foot candles, while Figure 2 shews a temperature of 60°F. as giving the highest assimilation rate at about 160 foot candles. If, however, one takes the mean values as given by the two sets of curves and plots, the temperature giving the maximum assimilation rate for any particular light intensity, one obtains the curve in Figure 3 which represents the sum of the

experimental evidence to date. The individual curves in Figures 1 and 2 serve to bring out clearly the type of interrelation existing between light temperature and assimilation in the cases studied.

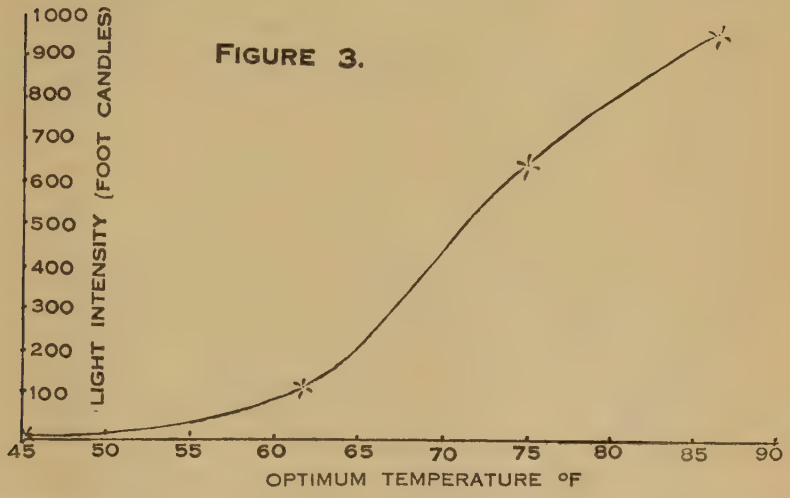


FIGURE 3.

Summary.

The interaction of light and temperature on the assimilation rate of seedling tomato plants of the variety E.S.1. is investigated and the importance of a suitable relation between these two factors is made clear. The bad effect of excessive temperature is shewn and the fact that the desirable temperature rises with the degree of illumination is brought out.

A graph shewing the approximate relation of the optimum temperature for assimilation to light intensity is given.

2. Water-Content and Assimilation of Seedling Tomato Plants.

R. MELVILLE.

Two parallel series of assimilation experiments were made during 1933. In one, determinations were made of the gain in dry weight during a seven hour assimilation period of seedling plants of the variety E.S.1 grown under normal conditions in a glasshouse. The second series was similar in all respects except that the plants were placed in darkness six hours before sunset on the day preceding the experiment, and uncovered at midnight. Accordingly, the length of the period of darkness

preceding the experiments varied at different times of the year in both series. The plants were in all cases grown to the eight leaf stage before use. The water-content of the plant tissues was calculated as a percentage of the fresh weight. The variation in water-content from plant to plant in any group of plants of the same age and grown under similar conditions was found to be small. Thus, in one sample of ten plants the extreme range of water-content was, for whole plant, 91·88% to 92·63%, for leaves, 89·97% to 91·00%. As a result of this low variability, quite small differences between the mean water-contents of groups of plants are significant.

The water-content of all parts of the plant falls during the day. The main cause of the reduction in water-content under the conditions of glasshouse culture was found to be the accumulation of assimilates in the plant, rather than the effect of external conditions as measured by the water loss of an evaporimeter. The correlation coefficient between the gain in dry weight of the leaves and their fall in water-content during the assimilation period was 0·936, with a significance of more than hundred to one. The correlation of fall in water-content with evaporimeter loss was not significant.

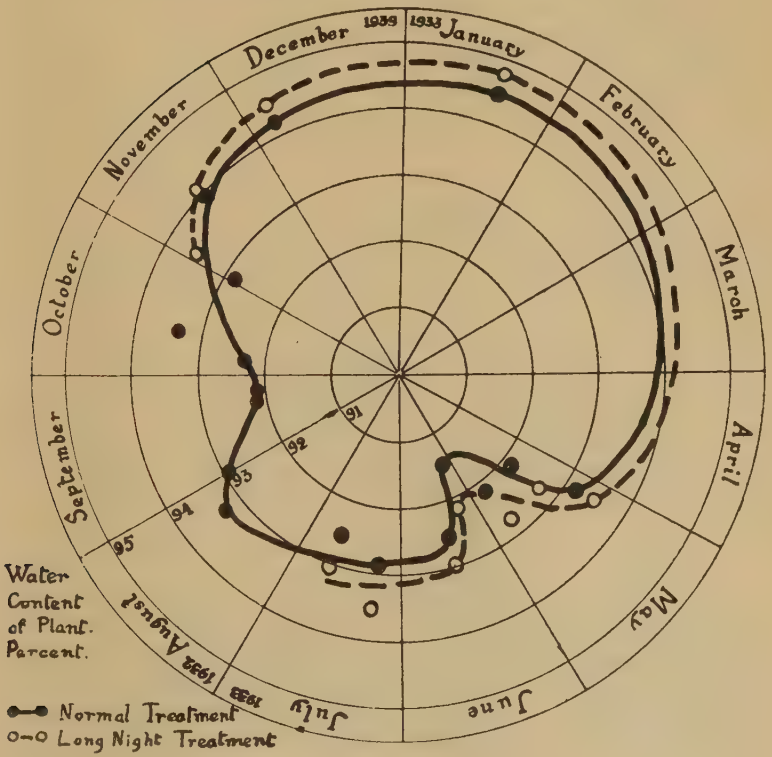
The seasonal drift in water-content is shewn in Figure 1. The mean water-content in the summer was found to be about 1% lower than in the winter, the values for the whole plant being summer, 92·86%, winter, 93·81%. The seasonal changes did not run a uniform course, but there were periods in early June and in late September when the water-content was much lower than the mean for the summer period. On June 9th, the mean water-content of the plants in the morning was as low as 91·49%. An explanation for the occurrence of these periods of low water-content was sought, temperature, sunlight, and length of day being considered. It was found that the low water-contents were obtained immediately before the heating of the glasshouse was discontinued in early June, and after heating was recommenced in September. The effect was most marked at the spring minimum when the mean night temperature was found to be relatively high. As a result of a high night temperature, the saturation deficit of the atmosphere was high, and this probably caused comparatively large water losses from the leaves. Under these conditions the plants were apparently unable to make good the fall in water-content resulting from the previous day's assimilation.

The assimilation rate as estimated from the gain in dry weight was high in spring and summer, and low in winter. On account of the frequency of fogs the lowest assimilation rate occurred in November, rather than at the time of the

"shortest day" in December. It would appear that light was the most important factor occasioning the seasonal drift in assimilation rate. The seasonal drift was not uniform but was marked by the occurrence of periods during which the assimilation rate was low. These periods coincided with the times of the water-content minima and suggested that water-content could control assimilation rate.

Figure 1.

The seasonal drift of water-content.

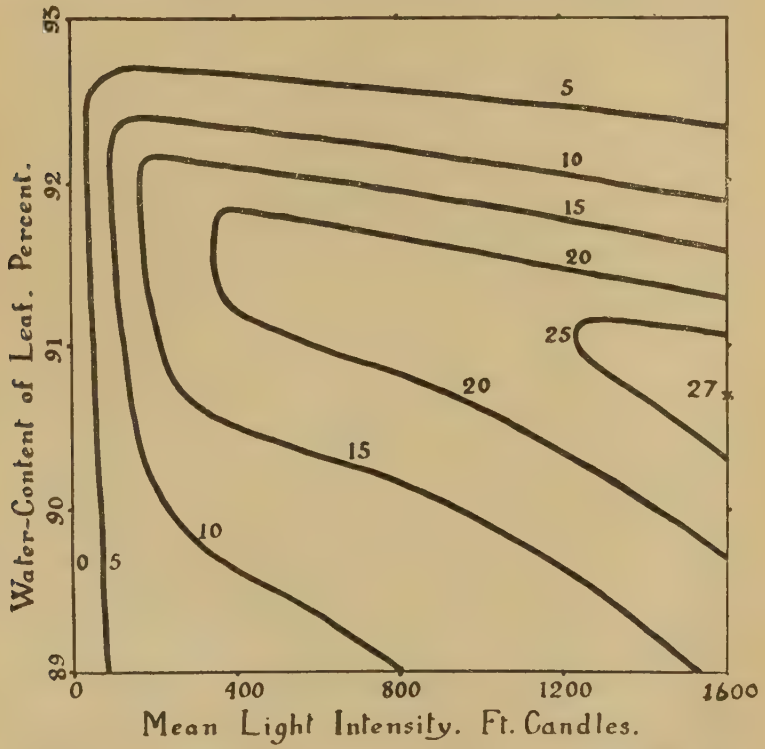


The complete series of results has been used in the construction of a three dimensional diagram in which water-content, mean light intensity, and gain in dry weight are represented. Assimilation rate increases fairly regularly with rising water-content until an optimal value is reached, after which, any further increase results in a sharp decline in

assimilation. The optimal water-content is dependent on the light intensity and decreases as light intensity increases. These features are evident from the contoured plan of the diagram, Figure 2.

Figure 2.

Plan of the solid diagram shewing the relationship between water-content, light Intensity, and gain in dry weight.



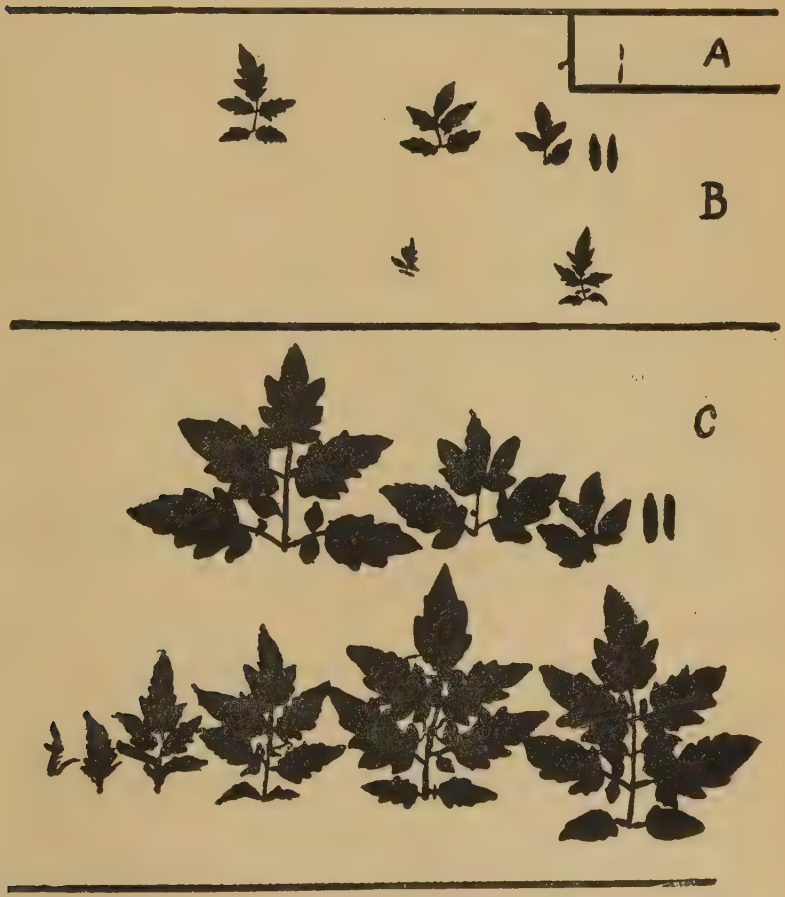
The contours represent the percentage gain in the dry weight of the plant.

Strong support to the views expressed above is provided by the results of the parallel series of experiments in which the plants were given six hours of darkness in addition to the normal night. The effect of the longer period of darkness was to raise the water-content. A higher assimilation rate followed in the subsequent period of light, except during the winter when the water-content was already supra-optimal. On the evidence of the control experiments, a reduction in the assimilation rate might be expected from a further increase in the water-content in the winter.

Plants possessing a supra-optimal water-content were of the "soft" type resulting from the short days and low light intensity of winter, and do not normally occur in the summer. It was desirable to determine the assimilation rate of plants with such high water-content under summer conditions. For this purpose a sowing of plants was subjected to eight hours

Figure 3.

Effect of shortening the day on growth.



A. Cotyledons at commencement of experiment.

B. Plant exposed to an eight hour day for four weeks.

C. Normal plant four weeks old grown with mean length of day of seventeen hours (natural daylight).

of light per day from the time their cotyledons had expanded until the eight leaf stage used in the experiments. The plants took eight weeks to reach this stage, and resembled the winter type of plant very closely. Other plants of the same sowing grown with the normal length of day reached a comparable stage of development in four weeks. A comparison of the normal plants with short day plants of the same age brings out some striking differences between their dry weight and leaf areas (Table 1 and Figure 3).

Table 1.

	Short day plants	Long day plants
Length of day	8 hours ...	17 hours
Period of growth	30 days ...	30 days
Dry weight of plant	0·09 gm. ...	1·74 gm.
Efficiency Index "k"	0·093 ...	0·191
Water-content of plant (morning)	93·05% ...	92·01%
Leaf Area, sq. cm.	33·3 ...	368·5

The short day plants were found to have a much lower assimilation rate than that of the normal summer type of plant with a slightly lower water-content. The result of the experiment supported the view that water-content could be supra-optimal. Further, it would appear that water-content tends to be too high in winter and too low in summer. It may be suggested that the practice of curtailing the watering of plants during the winter months with the object of obtaining a "harder" plant may also result in a higher assimilation rate, and an increase in the growth of the plant.

Summary.

(1) The water-content of tomato plants of the same age and history varies little from plant to plant.

(2) There is a seasonal drift of water-content from the summer value to a higher value in the winter. The uniformity of the drift is broken by the effect of stopping and of re-starting the glasshouse heating system.

(3) The assimilation rate increases with rising water-content until an optimal value is reached, after which assimilation falls rapidly with a further rise in water-content.

(4) There is evidence that water-content may become supra-optimal in winter.

3. Some Aspects of Translocation in the Seedling Tomato Plant.

I. W. Selman.

Although it is well known that the greater part of the carbon dioxide fixed by the plant is converted to carbohydrate by the green leaf, the influence of environmental factors on the movement of assimilates from the leaf into the stem and root is still relatively obscure. In this paper an attempt has been made to investigate the seasonal trend of translocation and to analyse the effect of some of the more obvious factors.

Seedling tomato plants of the variety E.S.1, raised in boxes of sterilized soil and transferred to "60" pots when the first rough leaves appeared, were used for experimentation when at the eight leaf stage. For any one experiment a batch of 70—80 plants were graded into ½ inch height groups and the plants then paired for leaf area, stem thickness and hardness as described by Bolas and Melville.* Twenty pairs are obtained from one sowing when possible and a partner, selected at random from each pair was sampled at the commencement, and the remainder at the end of the seven hour assimilation period. Sampling consisted in measuring the fresh weight of each stem, leaf and root, and drying each plant for about fifteen hours in a vacuum oven at a temperature of 70°C. to obtain the dry weight. The percentage change of each plant in relation to its partner was calculated, and the mean percentage change was found, by Fisher's modification of Student's method, to be highly significant. All weighings were carried out on spring balances constructed of phosphor-bronze wire. Translocation is expressed by the ratio—

$$\frac{\text{Absolute gain in dry weight—stem and root}}{\text{Absolute gain in dry weight—whole plant}} \times 100$$

one sample being taken at 9 a.m. and the other at 4 p.m., in the greenhouse with natural illumination.

Assimilation by the green stem is undoubtedly a factor affecting these results, but at present it is impossible to estimate the magnitude of this factor although preliminary observations suggest that the effects of stem assimilation are of minor importance in relation to the movement of assimilates from the leaves.

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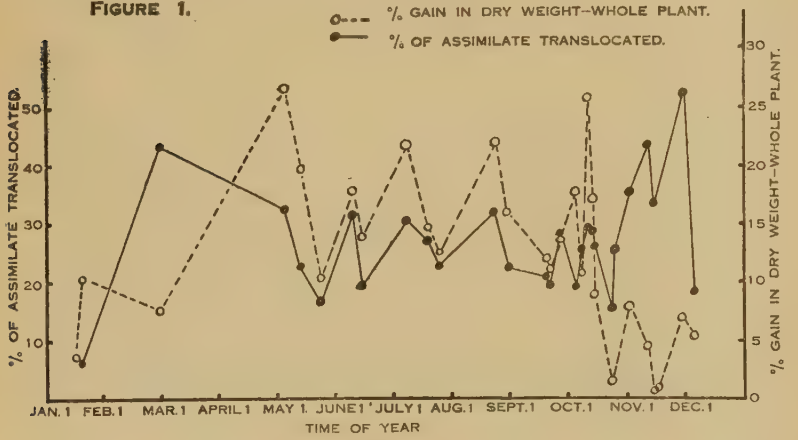
Seasonal changes in translocation.

Figure 1 shews the percentage change in dry weight of the plant—in the seven hour assimilation period, and the percentage of that dry material which is moved into the stem and root, expressed graphically through the year. It will be observed that in the summer months the ratio of the per cent. of assimilate translocated to the gain in dry weight of the plant approximates to a constant fraction. Towards the end of October, however, this ratio changes, apparently reaching a maximum at the end of November.

FIGURE 1.



The striking difference in the quantities of material translocated during the assimilatory period in summer and in winter may best be illustrated by actual figures. Thus, on November 10th, the plant gained 4½% in dry weight and 43% of this material passed out of the leaf, and on July 7th the plant gained 22% in dry weight and only 30% of this was translocated. If one remembers that there are 15 hours of darkness in the November night and but 9 hours in the July night, periods in which the plant is losing weight by respiration and the leaf, also by translocation, one begins to visualise more clearly the conditions leading to the familiar winter check in plant growth.

It would appear that the demands made on the leaf by stem and root with the onset of short days and low light intensities are not immediately diminished in proportion to the reduced assimilatory rate of the leaf. Presumably this unsatisfactory balance cannot continue, with the result that root growth almost ceases in December and the percentage of assimilate translocated tends to return to a value approaching the summer condition.

The varying reactions of summer and winter plants are expressed in Figures 2 and 3 by correlation diagrams between the percentage gain in dry weight plant and the percentage of assimilate translocated. Summer plants may be regarded as "normal," remembering that the tomato is naturally of subtropical habitat. Figure 2 suggests that the rate of trans-

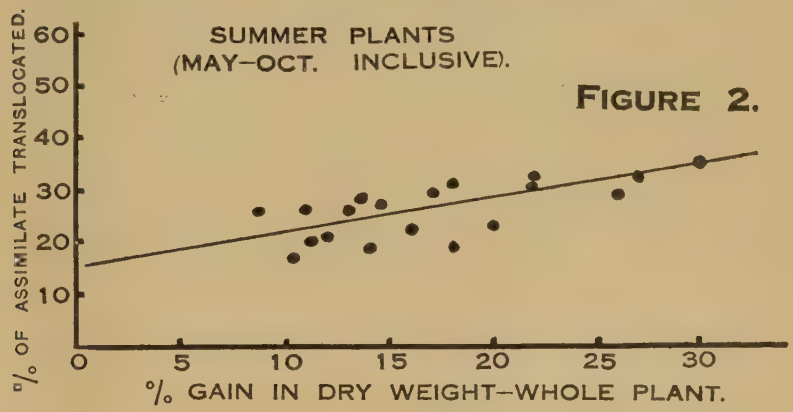


FIGURE 2.

location, under summer conditions, is directly proportional to the rate of assimilation. In the winter months, however, practically no correlation is found to exist between assimilation and translocation (Figure 3), suggesting that factors other than concentration gradients are of increasing importance in controlling the distribution of assimilates and hence ultimately, the structure and type of plant. Indications have been obtained that light, temperature, and the balance between light

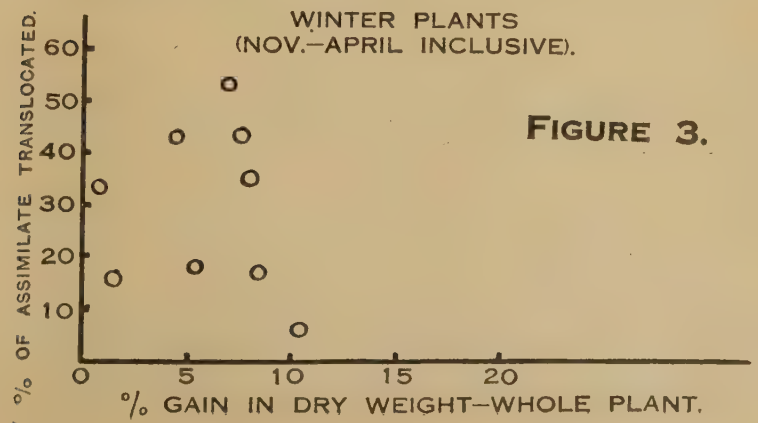


FIGURE 3.

and temperature are factors of great importance in this respect, and an electrical conductivity method for the determination of the permeability of the cells of the leaf is proving of value, although but little information is yet available.

Effect of light on translocation.

By calculating the observed translocation as a percentage of that expected from the mean straight line in Figure 2, and plotting this against the mean light intensity recorded during the assimilation period, Figure 4 is obtained. The curve in Figure 4 is calculated by the method of least squares. Translocation rate thus appears to fall with rise of light intensity reaching a minimum at about 1,000 foot candles and then rising again. The rise observed above this light value may be due to an increase in soluble and possibly mobile, carbohydrates in the cells of the leaf, perhaps a concomitant of a change in the water relations of the cells brought about by closure of the stomata.

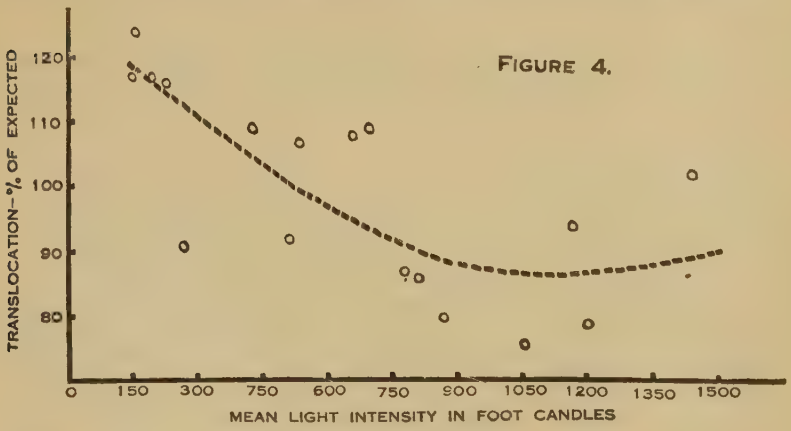


FIGURE 4.

Effect of other factors on translocation.

Only preliminary studies of the effect of temperature on translocation rate have been made, and although undoubtedly of great importance, no simple correlation can at present be defined.

Water content of the tissues appears to affect translocation only secondarily in so far as assimilation rate may be controlled by this factor.

Changes in enzyme content of the leaf and changes in the relative amounts of carbohydrate-conducting tissue (phloem) in leaf and stem are all factors to be considered in this respect.

Experiments based on differing inorganic and mechanical soil constituents might well throw further light on the subject.

Practical applications.

The time taken for plants to reach the eight leaf stage has been found to vary from 6—12 weeks from the time of sowing, depending on the season, and a more detailed study of the factors controlling the translocation—assimilation ratio might well help in solving the problem of producing seedling plants of the normal summer type, more rapidly during the winter months. Although it is recognised that light is the chief factor controlling assimilation during the winter months and the absolute size of the plants must necessarily be limited by the amount of radiant energy available, it should still be possible to produce healthy plants by careful control of soil conditions, temperature-light balance and water relations.

6. Miscellaneous Investigations.

1. Plant Injury following the Burning of Sulphur in Glasshouses.

W. H. Read and O. B. Orchard.

A peculiar form of injury has been noticed on the foliage of chrysanthemums when they are grown in glasshouses after tomatoes and cucumbers, and in which sulphur has been burnt, following the removal of these crops, to destroy fungus and insect pests remaining in the houses. The first signs of damage may appear within a few days of introducing the chrysanthemums into the fumigated houses, a damp or foggy night being followed by the appearance of scorched or withered buds and growing tips.

Dark brown patches, often accompanied by white deposits around the edges, appear on the upper leaves and petioles of the plants. These patches, which may either be quite small or may cover the entire leaf, rapidly shrivel and dry up. Dark brown sunken areas occur on the sides of the flowering and main stems, which give rise to distorted and curled growth. During the past season, several instances have occurred where the flower buds have been so seriously damaged that the crop has become a complete loss.

It has not been possible to implicate a fungus or bacterial disease or an insect pest as being responsible for this damage, and recent investigation has shewn that, in many cases, it is caused by the presence of zinc sulphate in the drip from the overhead galvanised wires that normally support the tomato or cucumber crops.

During the past season, extensive damage following fumigation by burning sulphur has occurred in houses not fitted with wires, and has been proved to be due to the presence of zinc sulphate in the drippings from the painted surfaces, the paint in all cases containing zinc oxide as the pigment. The condensation of moisture in the houses is sufficient to cause a drip from the structure or wires, and thus carries zinc sulphate in solution to the foliage and buds of the plants.

In one block of houses erected in March and fumigated by burning sulphur before bringing in chrysanthemums, the drippings from the painted wood at the period when damage was most pronounced were found to be saturated with zinc

sulphate. It was also found that the liquid drippings from the wires of a house recently fumigated by burning sulphur caused the appearance of burnt patches on chrysanthemum leaves in from four to five hours after being placed on the leaves.

Confirmation as to the cause of the damage was obtained by the detection of zinc in the damaged portions of plants sent in for examination, and the production of the same type of injury by splashing chrysanthemum plants with solutions of zinc sulphate. The maximum amount of this chemical tolerated by chrysanthemum plants without noticeable injury was one part of the ordinary crystalline salt in three hundred parts of water.

It has been proved that soluble zinc salts result from the combustion of sulphur in houses containing galvanised wire, or painted internally with "zinc-white" paints, by burning sulphur at the rate of 1 lb. per 1,000 cu. ft. in a house in which were placed some lengths of galvanised wire and some pieces of board treated with samples of paint suspected of causing "drip" injury. On examination the following morning, it was possible to dissolve from the paint, zinc sulphate at the rate of approximately $\frac{1}{8}$ oz. of the crystalline salt per sq. ft. of painted surface, whilst the wires were covered with crystals of the same substance. The amount of free sulphuric acid in the moisture condensed on the glass was negligible, and very little zinc sulphite was present in the paint or on the wires. The extent to which zinc sulphate was formed by the action of the sulphur dioxide derived from the burning of sulphur and the subsequent oxidation of the sulphite to sulphate may be dependent in some measure upon the amount of moisture in the house during fumigation, but whilst little may be formed under very dry conditions, it is probable that such conditions are not conducive to effective destruction of fungus spores so that fumigating a very dry house would not have the desired disinfecting action.

An additional test in which flowers of sulphur were dusted on the staging, floor and hot water pipes in a house in which were placed boards painted with the same paint shewed that there is no danger of the formation of sufficient zinc sulphate to cause drip injury when sulphur is used for dusting purposes. In no circumstances was damage caused by the drip from wood painted with lead paint and fumigated with burning sulphur.

Where houses painted internally with paint containing zinc have been fumigated by burning sulphur, the possibility of subsequent damage can be greatly minimised by thoroughly hosing down with water at frequent intervals. This is most effective when the interior of the house is wet, due

to condensed moisture having taken into solution part of the zinc sulphate. When the trouble is due to the wires only, it is advisable to slide these to the bottom of the supporting posts underneath the gutters.

Where conditions are such that hosing down cannot be undertaken, the only remedy is to prevent dripping by maintaining a dry atmosphere.

Since the formation of soluble zinc sulphate must cause a partial destruction of the paint, alternative methods or fumigating the houses should be adopted by using naphthalene or formaldehyde. The use of paint with a lead or barium sulphate base would be one means of counteracting the trouble with painted surfaces.

This note has been published because the numerous inquiries received at this station shew that injuries from the above cause are both widespread and numerous.

2. Conditions which affect the quality of Tomatoes.

W. F. Bewley, W. H. Read, and O. B. Orchard.

During last August and September, complaints were made by certain provincial markets that tomatoes arriving at these markets were not up to standard. It was said that the fruits were blotchy and unduly soft.

Investigation shewed that these complaints were justified to some extent, and an attempt was made to discover the cause of these troubles, with a view to prevention.

A complete report is not possible at this stage of the work, but information obtained already should prove helpful during the coming season.

Poor quality tomato fruit may be classified into five main types.

(*a*) Blotchy ripening due to inadequate potash supply.

(*b*) Green back partly due to insufficient potash and partly to the top of the fruit becoming too hot through exposure to intense sunlight.

(*c*) Mosaic disease.

(*d*) A yellow mottle due to imperfect plants and high temperatures.

(*e*) Premature softness due to insufficient ventilation of the boxes.

In this report it is proposed to deal with the yellow mottle (*d*) and premature softness (*e*), because these disorders may not be noticeable at the time of packing, whereas true blotchy ripening, green back and symptoms of mosaic disease are usually distinguishable in the packing shed and can be discarded from the best grades.

Irregular ripening.

To appreciate the problem fully it is necessary to know something of the distribution of colour in the tomato.

The red pigment lycopin is related to the yellow pigment carotin of which it is an isomer. It is present in the flesh. The yellow pigment carotin and possibly also Xanthophyll occurs in the flesh and in the walls of the epidermis.

The commercial tomato has carotin in the skin and also carotin and lycopin in the flesh.

The peach tomato does not contain carotin, and the colour is produced by the red pigment shewing beneath a colourless skin. The dark yellow tomato has no lycopin, but there is carotin in both the skin and the flesh while the pale yellow varieties have carotin only in the flesh.

It will be seen at once that the uniform red colour of the commercial tomato depends upon the uniform distribution of the red pigment in the flesh, and this distribution being the result of a metabolic process must depend upon the health of the plant.

It is a well-known fact that the degree of redness of the tomato is affected by temperature, but is independent of any direct effect of light.

Fruit will redden perfectly in darkness at a temperature of 68° to 77°F. (20° to 25°C) or even 80°F., but at higher temperatures the production of red pigment is retarded and the fruit turns an orange or yellow colour as the temperature is increased.

The experimental results shewn in Table 1 will help to explain this further.

In these experiments the fruit were picked at 3 p.m., after the heat of the day. They were packed in the incubator as quickly as possible, and all shewed just a suspicion of red colour.

The results indicate four important points.

(1) Some fruits develop a general yellowish colour under high temperatures, while in others there are distinct yellow patches in addition. This brings out the inherent tendency to blotchiness in some fruits.

Table 1.

Series	Temperature during test	Time of exposure in hours	Effect on fruit in open trays	Time taken to recover in hours
1	88°F.	24	Yellow tinge: uniform in some: patchy in others: fruit firm	Not more than 24
2	,,	48	Yellowing more pronounced than 1: patches more distinct: fruit firm ...	Not more than 48
3	,,	96	Yellowing more pronounced than 2: patches more distinct: fruit firm ...	Not more than 96
4	,,	114	Yellowing more pronounced than 3: patches more distinct: fruit firm ...	Notmore than 120
5	60°F.		Normal colour...	
6	96°F.	24	Yellowing pronounced as in 3: distinct patches in some: fruit firm ...	Not more than 48
7	,,	48	Yellowing more pronounced than 6: distinct patches in some: fruit firm	Not more than 72
8	,,	96	Yellowing more pronounced than 7: distinct patches in some: fruit firm	Not more than 120
9	60°F.		Normal colour...	
10	108°F.	14	Yellow colour pronounced: little red colour: patchy: firm	Not more than 120
11	,,	48	Very yellow and patchy: firm	——
12	60°F.		Normal colour	

(2) The abnormal colour disappears in time when the fruit is stored at suitable temperatures. When the length of exposure is not longer than what could occur during marketing, the fruit has recovered within three days.

(3) When the fruit was ripened at 60°F., normal colouring occurred and there was practically no blotchiness.

(4) Exposure to high temperatures under the conditions of the experiment did not cause the fruit to become soft.

In considering those fruits where the colour change is uniform over the entire fruit in contrast to those which develop patches of a more intense yellow colour; it seems possible to explain this by supposing that in the flesh of the latter the amount of lycopin produced under normal conditions varies in different parts of the flesh. In the areas where the amount of lycopin is small, the rate of lycopin formation is slow. This is still further retarded at high temperatures and gives rise to the yellow patches. This emphasises the inherent tendency of some fruits to ripen irregularly when conditions are unfavourable.

Careful investigation of the crop from strong healthy plants and that from weak plants with poor root development and diseased roots, indicate that the inherent tendency to develop these market troubles arises as the result of a weakened constitution, but that given improved methods of packing and marketing, the conditions may be such that the tendency to those disorders which affect quality is prevented from developing.

The experiment also indicates that the same effect can be obtained by exposure to 88°F. for long periods and a higher temperature, 108°F. for a short period.

Inherent susceptibility.

Although during the period of a few months it is impossible to gain all the information desired, it has been possible, as the result of experiments, to shew that inherent susceptibility may arise in different ways.

(*a*) Weak plants, with diseased root systems show high susceptibility from the 6th truss onwards.

(*b*) It is also shewn earlier on unduly soft plants.

(*c*) The best fruit come from well balanced plants with large healthy root systems.

(*d*) During the summer of 1933, the best fruit came from houses where shade was provided by a canopy of leaves towards the top of the house, or where the glass was shaded.

(*e*) Where transpiration was reduced in this way or by overhead damping the fruit was good.

(*f*) Where the air temperature was high, the air dry, and there was no shade, the quality was worst.

The following suggestions are offered as preventative measures:—

(1) During summers like that of 1933 with long periods of intense sunshine, periodical dressings of a nitrogenous fertiliser such as dried blood helps to maintain a balanced growth. Mulching is also an advantage for it helps to maintain a uniform degree of moisture in the soil.

Potash, the fertiliser necessary for good quality fruit, must not be forgotten. Early top dressings are essential.

(2) Good root development is essential and far too little knowledge is available concerning root growth.

Soil sterilization has been blamed for poor quality fruit in some quarters. This is not correct, for quality is impoved by soil sterilization provided the following crop is grown sensibly and in true balance. Forcing after sterilization will affect the quality adversely.

Methods for soil amelioration include the use of such materials as clean straw and thorough cultivation of the second spit.

(3) Some districts are not favourable to early crops. If they must produce early crops it should be realised that the stamina of the plant and the quality of the fruit will suffer later.

If early crops are necessary they should be treated as special cultures.

Plants planted in March are more likely to yield high quality fruit than earlier plantings.

(4) Shading, overhead damping, increased ventilation and frequent applications of small quantities of water should be used to a greater extent than at present.

The injurious effect of high temperatures operates from the time the fruit begins to swell until the boxes are opened in the market.

It follows that if the fruit has been kept sufficiently cool before it leaves the nursery high temperatures during transport will have the least serious effect. If the fruit has been submitted to high temperatures before despatch high temperatures during transport will cause serious trouble.

Noticeable mottling of the fruit can be caused by the following treatments:—

36 hours	at	88°F.	recovery in	24	hours.
24 „	„	96°F.	„	48	„
12 „	„	108°F.	„	120	„

A box packed at 10 a.m. one day should be sold by 10 a.m. the next day and would require a temperature of 96°F. or more during that period to cause objectionable mottling.

The fruit would in any case recover a normal colour if kept long enough under cool conditions.

It will be seen from the above that fruit from some districts would be at its worst when the boxes are opened at the market, and would recover a normal appearance after being exposed for sale in a cool shop for forty-eight hours.

In this respect fruit picked on the turn would be worse than that picked in a riper condition.

Normally coloured fruit could be obtained by ripening it under suitable conditions before packing or after reaching the market.

Presumably fruit from abroad passes through the badly coloured stage during thirty-six hours after packing and then regains a more normal condition during the cool period prior to reaching market.

As the effect of temperature is felt from the time the fruit commences to swell until it reaches the consumer the following suggestions are offered:—

(1) The house must be kept as cool as possible.

(2) The fruit should be picked early in the day and during hot spells not later than 10 a.m.

Failing that it should be kept under cool conditions over night.

(3) Fruit should not be left standing in boxes in the house or in the sun. It should be taken to a cool shed.

(4) It should not be packed in a hot condition.

Premature softness.

The results of experiments relating to softness are shewn in Table 2.

The experiments shew clearly the effect of storing tomatoes in an air-tight or nearly air-tight condition.

Table 2.

Series	Treatment	Temp.	Effect after 60 hours	Effect after 120 hours
1	Trays outside in shade		Ripest fruit: good colour: firm ...	Good quality: good colour: firm: good calyx
2	Trays in the dark ...		Next best: colour not so good: firm	Next best: colouring somewhat uneven: firm
3	In a tightly stoppered glass jar: in shade		Ripening retarded: firm	Little colour change: fruit soft: bad odour internal breakdown beginning
4	As 3	88°F.	Rather more colour than 3: soft ...	As 3, but worse: fruit very soft
5	Wrapped in grease-proof paper in dark		Uneven colouring: soft	Fruit bad colour, water soaked condition: soft: bad odour
6	As 5	88°F.	Same as 5, but much worse ...	Same as 5, but much worse

When fruits are stored in an air-tight container ripening is retarded, the fruits become soft after the third day and a disgusting odour is given off. In the case of fruit wrapped in oiled papers, which exclude the air, the effect is similar, but is, of course, not so marked. Further the bad effect of air deficiency is worse as the temperature increases. Without ventilation the acid content of the fruit becomes abnormally high and the soluble carbohydrates (sugars) are low. This indicates incomplete oxidation of carbohydates to CO_2 with consequent accumulation of acids and peculiar flavour.

Although the conditions in these experiments are abnormal they do suggest that good flavour and firmness depend upon an adequate supply of oxygen in the container.

Having obtained these results a further series of experiments were arranged with tomatoes packed in different ways. These are explained in the following table :—

Table 3.

Series.	Method of packing.	Temp.	Condition of fruit.	
			After 36 hours.	After 72 hours.
1.	Open tray	60	Firm	Firm ... ...
2.	Box: wood wool top and bottom ...		Firm	Few soft ...
3.	Box: wood wool and cardboard top and bottom		Some soft ...	Many soft ...
4.	Box: wood wool, cardboard & paper top and bottom ...		Softer than 3 ...	Many softer than 3 ... ...
5.	As 4, but wrapped in brown paper ...		Many soft fruit	As 4: probably a a little softer still

The above experiment was repeated at a temperature of 88°F. Series one was affected only in colour, but the others were much softer than those at 60°F.

The above results confirm those of the previous experiments and show that at certain times of the year the present method of packing does not allow the fruit to obtain sufficient air for ideal ripening.

They shew that a great deal of work must be done with the object of improving the type of container and the method of storage during transport.

It will be obvious that in addition to designing a container which will permit the free circulation of air around each fruit, strips of wood must be nailed around the box to prevent them from being stacked closely together. Circulation of air freely through the stack is as necessary as that in the box. The work will be continued.

APPENDIX A.

PUBLICATIONS.

1919.

Paine, S. G. and W. F. Bewley. Studies in Bacteriosis IV. "Stripe" Disease of Tomato. Ann. App. Biol., Vol. VI, Nos. 2 and 3, pp. 183-202.

1920.

Bewley, W. F. "Damping off" and "Foot-rot" of Tomato Seedlings. Ann. App. Biol., Vol. VII, Nos. 2 and 3, pp. 156–172. Journ. Min. of Agric., Vol. 27, pp. 670–673, Oct.

Lloyd, Ll. The Habits of the Glasshouse Tomato Moth, *Hadena* (Polia) *oleracea* and its Control. Ann. App. Biol., Vol. VII, No. 1, pp. 10–19, Sept.

Paine, S. G. and W. F. Bewley. "Stripe" Disease of the Tomato. Journ. Min. of Agric., Vol. 26, pp. 998–1,000, Jan.

1921.

Bewley, W. F. Control of "Damping off" and "Foot-rot" of Tomatoes. Journ. Min. of Agric., Vol. 28, pp. 653–654, Oct.

Bewley, W. F. and W. Buddin. On the fungus flora of Glasshouse Water Supplies in relation to Plant Disease. Ann. App. Biol., Vol. VIII, No. 1, pp. 10–19, June.

1922.

Bewley, W. F. "Sleepy Disease" of the Tomato. Ann. App. Biol., Vol. IV, pp. 116–134, June.

Bewley, W. F. Anthracnose of the Cucumber under Glass. Journ. Min. of Agric., Vol. 29, pp. 469–472, Aug., 1922, and pp. 558–562, Sept.

Bewley, W. F. "Tomato Diseases." Journ. Roy. Hort. Soc., Vol. XLVII, Pts. 2 and 3, pp. 169–174.

Lloyd, Ll. The Control of the Greenhouse White Fly, with notes on its biology. Ann. App. Biol., Vol. IX, No. 1, pp. 1–34, April.

1923.

Bewley, W. F. Diseases of Glasshouse Plants. Messrs. E. Benn, Ltd., Sept.

Bewley, W. F. "Sleepy Disease" of the Tomato. Journ. Min. of Agric., Vol. 30, pp. 450–457.

Owen, O. Carbon Dioxide in relation to Glasshouse Crops. Part I. Ann. App. Biol., Vol. X, Nos. 3 and 4, pp. 312–317, Dec.

Owen, O. and P. H. Williams. Carbon Dioxide in relation to Glasshouse Crops. Part II. Vol. X, Nos. 3 and 4, pp. 318–325, Dec.

Paine, S. G. and W. F. Bewley. Further Investigations of the "Stripe" Disease of Tomato. Ann. App. Biol., Vol. X, pp. 89–95, Feb.

Speyer, E. R. Mycetophilid Flies as Pests of the Cucumber Plant in Glasshouses. Bull. Ent. Res., Vol. XIII, Pt. 3, pp. 255–259.

1924.

Bewley, W. F. and J. Shearn. A Root Disease of the Tomato caused by *Colletotrichum tabificum* (Hallier pro parte) Pethybridge. Ann. App. Biol., Vol. XI, pp. 244–251, No. 2, July.

Speyer, E. R. and O. Owen. The action of some Organic Compounds upon the Cucumber House Wood-louse. Ann. App. Biol., Vol. XI, pp. 236–243, No. 2, July.

1926.

Bewley, W. F. Practical Soil Sterilisation by Heat for Glasshouse Crops. Journ. Min. of Agric., Vol. 33, pp. 297–311, July.

Bewley, W. F. Note on the Preservation of Plate Cultures of Fungi. Ann. App. Biol., Vol. XIII, No. 4, pp. 577–579. Nov.

Bewley, W. F. and H. L. White. Some Nutritional Disorders of the Tomato. Ann. App. Biol., Vol. XIII, No. 3, pp. 323–338, Aug.

Owen, O., T. Small and P. H. Williams. Carbon Dioxide in relation to Glasshouse Crops. Part II, Ann. App. Biol., Vol. XIII, No. 4, pp. 560–576, Nov.

1927.

Speyer, E. R. An important Parasite of the Greenhouse White Fly (*Trialeuodes vaporariorum*, Westwood). Bull. Ent. Res., Vol. XVII, Pt. 3, March.

Small, T. Rhizoctonia "Foot-rot" of the Tomato. Ann. App. Biol., Vol. XIV, No. 3, pp. 290–295.

1928.

Small, T. A Disease of the Strawberry Plant. Journ. of Pomology and Hort. Sci., Vol. VII, pp. 212–215. Dec.

1929.

Bewley, W. F. The Effect of Environmental Conditions on Plant Diseases under Glass. Ann. App. Biol., Vol. XVI, No. 1, pp. 190–192, Feb.

Bewley, W. F. The Influence of Bright Sunshine upon the Tomato under Glass. Ann. App. Biol., Vol. XVI, No. 2, May.

Bewley, W. F. The Practical Sterilisation by Heat of small quantities of Soil. Journ. Min. of Agric., Vol. 36, pp. 623–634, Oct.

Owen, O. The occurrence of Chlorates in a Tomato Soil. Journ. of Pomology and Hort. Sci., Vol. VII, No. 4, pp. 270–275, June.

Owen, O. The Effect of Copper Sulphate on Tomato Plants. Ann. App. Biol., Vol. XVI, No. 3, pp. 430–437, Aug.

Small, T. Temperature and Humidity in relation to Tomato Leaf Mould. Ann. App. Biol., Vol. XVI, No. 1, pp. 192–193, Feb.

White, H. L. The Wilt Disease of the Carnation. Journ. of Pomology and Hort. Sci., Vol. VII, pp. 302–323, June.

1930.

Bewley, W. F. Some Experiments on the Heating of Glasshouse Soil by Electricity. Rep. and Proceedings, IXth Internat. Hort. Congress, London, Aug.

Bewley, W. F. and B. D. Bolas. Aucuba or Yellow Mosaic of the Tomato Plant: Reaction of Infected Juice. Nature, Jan. 25th.

Bewley, W. F. and W. Corbett. The "Maturation Period" of the Tomato Plant. Ann. App. Biol., Vol. XVII, No. 2, pp. 267–279, May.

Bewley, W. F. and W. Corbett. The Control of Cucumber and Tomato Mosaic Diseases in Glasshouses by the use of Clean Seed. Ann. App. Biol., Vol. XVII, No. 2, pp. 260–266, May.

Jozefowicz, Mary. The Effect of certain Treatments on the Germination of Tomato Seeds. Ann. App. Biol., Vol. XVII, No. 3, pp. 504–513.

Jozefowicz, Mary. Some Observations on Tomato Plants from Seed submitted to High Temperatures. Ann. App. Biol., pp. 514–521.

1930.

Small, T. The Relation of Atmospheric Temperature and Humidity to Tomato Leaf Mould (*Cladosporium fulvum*). Ann. App. Biol., Vol. XVII, No. 1, pp. 71–80, Feb.

Small, T. and H. L. White. Carbon Dioxide in relation to Glasshouse Crops. Part IV, Ann. App. Biol., Vol. XVII, No. 1, pp. 81–89, Feb.

1931.

Bewley, W. F. The Nature of the Virus Principle in Mosaic Disease. Nature, March 21st, 1931.

Bewley, W. F. Practical Soil Sterilisation with special reference to Glasshouse Crops. Bull. No. 22, Min. of Agric.

Owen, O. The Analysis of Tomato Plants. Part II. The Effect of Manurial Treatment on the composition of Tomato Foliage. Journ. Agric. Sci., Vol. XXI, Part II, pp. 442–451, July.

Small, T. Experiments on the Control of Tomato Leaf Mould (*Cladosporium fulvum*) by Fungicides and Fumigants. Ann. App. Biol., Vol. XVIII, No. 3, pp. 305–312, Aug.

1932.

Bewley, W. F. and O. B. Orchard. The Control of Tomato Leaf Mould. Ann. App. Biol., Vol. XIX, No. 2, pp. 185–189, May.

Read, W. H. The Toxicity of the Vapours of Volatile Organic Compounds to the "Red Spider" Mite (*Tetraychus telarius* L.). Ann. App. Biol., Vol. XIX, No. 3, pp. 432–438, Aug.

1933.

Ainsworth, G. C. An Investigation of Tomato Virus Diseases of the Mosaic "Stripe" Streak Group. Ann. App. Biol., Vol. XX, No. 3, pp. 421–428, Aug.

APPENDIX B.

Manurial Treatment in Tomato Experiments.

(1) Lime.

All Houses except 1, 11 and 12 received ground caustic lime at the rate of 2 tons per acre.

(2) Stable Manure.

Houses, 1, 2, 7—10, 11 and 12 received 15 tons per acre.

(3) Base-dressing.

House 1 received 10 cwts. hoof and horn, and 10 cwts. sulphate of potash per acre.

House 2 and 5 received ¾ lb. per sq. yd. of the following mixture:—

1 part bone meal.
1 part bone flour.
1 part hoof and horn.
1 part sulphate of potash.

House 6, 7—10, 11 and 12, received ¾ lb. per sq. yd. of the following mixture:—

1 part bone meal.
1 part bone flour.
1 part sulphate of potash.

(4) Top-dressing.

Houses 2, and 5 to 12, received 2 ozs. per sq. yd. of the following mixture every 14 days at discretion:—

3 parts sulphate of ammonia.
2 parts dried blood.
7 parts 30% superphosphate.
5 parts pure dissolved bones.
½ part bone flour.
2½ parts sulphate of potash.

This gave 5% ammonia, 24% total phosphates, 12% soluble phosphates, and 7% potash on examination.

Appendix C.

Manures applied to Plots 1-3, and 14-16 in Tomato Houses 3 and 4.

Plot.	TITLE.	Base Manure in Lbs. per sq. yd.				† Top-dressing in Lbs. per sq. yd.			
		Lime.	Stable Manure.	Basic Slag.	Sulphate of Potash.	Super-phosphate.	Sulph. of Ammonia.	Nitrate of Soda.	Sulph. of Potash.
1	Complete Artificials (I.) without Nitrogen	1.0	—	0.4	0.1	0.5	—	—	0.2
2	Unmanured	1.0	—	—	—	—	—	—	—
3	Complete Artificials	1.0	—	0.4	0.1	0.5	0.2	0.2	0.2
14	Complete Artificials with Dung	1 0	7	0.4	0.1	0.5	0.2	0.2	0.2
15	Complete Artificials without Phosphates	1.0	—	—	0.1	—	0.2	0.2	0.2
16	Complete Artificials without Potash	1.0	—	0.4	—	0.5	0.2	0.2	—

† The Top-dressing was applied in eight equal instalments.

Manurial Treatment in House 3, and Plots 4-13 in House 4.

FERTILISERS IN POUNDS PER SQUARE YARD.

House.	Plot.	Base.					Top-dressing.					
		Bone Flour.	Sulphate of Potash.	Cyanamide.	Hoof and Horn.	Shoddy.	Sulph. of Ammonia.	Nitrate of Soda.	Nitrate of Lime.	Dried Blood.	Peruvian Guano.	Fish Manure.
3	1 5 14	0.25	0.25	—	—	—	0.48	—	—	—	—	—
3	6 9 13	0.25	0.25	—	—	—	—	0.65	—	—	—	—
3	8 11 15	0.25	0.25	0.64	—	—	—	—	—	—	—	—
3	3 7 16	0.25	0.25	—	—	—	—	—	0.93	—	—	—
3	2 4 10 12	0 25	0.25	—	0.86	—	—	—	—	—	—	—
4	7 12	0.25	0.25	—	—	—	—	—	—	0.86	—	—
4	4 10	0.25	0.25	—	0.86	—	—	—	—	—	—	—
4	5 9	0.25	0.25	—	—	—	—	—	—	—	0.80	—
4	8 11	0.25	0.25	—	—	—	—	—	—	—	—	1.18
4	6 13	0.25	0.25	—	—	0.86	—	—	—	—	—	—

Appendix D.

Dates of Cultural Operations during 1932—1933.

Crop.	Sown.	Potted into 60's.	Potted into 32's.	Planted out in borders.	First Mulching.	First Top Dressing.	First Fruit Picked.	Last Fruit Picked.
Cucumbers	Dec. 29 1932	——	Jan. 23 1933	Feb. 17 1933	Mar. 7 1933	Mar. 13 1933	Mar. 24 1933	Sept. 1 1933
Tomatoes	Dec. 28 1932	Jan. 19 1933	——	Mar. 3 1933	——	May 9 1933	May 15 1933	Oct. 20 1933

Meteorological Records, 1933.

Month.	Air Temperatures						Grass Temp.			Rainfall				Mean Soil Temperatures		Hygrometer				Bright Sunshine		Barometer
	Mean		Absolute Max.		Absolute Min.		Av. Min.	Absolute Min.		Total Precipitation	No. of Days Pptn	Greatest Fall				Dry Bulb	Depres. of Wet Bulb	Relative Humidity %	Dew Point	Total No. of Hrs.	Daily Average.	
	Max.	Min.	Tem.	Date	Tem.	Date		Tem.	Date			Amt.	Date	1 ft.	2 ft.							
	°F.	°F.	°F.		°F.		°F.	°F.		Ins.		Ins.		°F.	°F.	°F.	°F		°F.			Ins.
January	40.7	31.4	57.0	3rd	21.0	22nd	29.51	18.0	27th	1.3	12	0.35	4th, 15th	33.7	41.3	31.3	0.5	85.8	35.4	51.3	1.6	29.105
February	47.0	39.0	57.0	3rd	21.5	23rd	31.7	20.0	23rd	1.26	10	0.35	25th	39.0	40.2	42.0	1.0	90.0	30.2	78.5	2.8	29.980
March	56.7	35.0	67.5	28th	26.5	20th	33.5	25.0	20th	2.21	12	0.63	16th	42.0	42.8	50.0	1.6	89.0	45.0	166.5	5.3	29.933
April	62.0	35.3	74.0	8th, 15th	29.0	18th	36.2	26.0	18th	1.00	8	0.30	25th	48.0	48.0	53.0	4.2	74.0	44.3	135.4	4.3	30.103
May	66.6	45.0	79.7	24th	36.5	27th	43.2	35.0	14th	1.89	15	0.47	6th	56.0	55.2	58.0	4.5	77.5	48.6	138.8	4.6	29.950
June	72.1	49.8	86.0	6th	42.0	12th	47.0	40.5	12th	2.09	12	0.61	23rd		61.3	66.2	8.0	60.4	51.1	210.5	7.0	29.886
July	78.7	54.0	95.0	29th	42.5	12th	53.0	42.5	12th	0.69	10	0.22	11th	66.2	64.8	70.0	7.0	65.7	57.2	225.1	7.2	30.100
August	78.0	52.0	90.5	29th	43.0	23rd	50.0	40.0	23rd	0.55	6	0.22	22nd	66.0	65.0	70.0	9.0	60.0	55 1	254.3	8.2	30.020
September	71.2	49.0	78.5	6th	36.5	14th	47.0	34.0	14th	2.77	13	0.72	23rd	59.7	61.5	62.0	4.3	76.0	55 7	146.8	4.9	30.060
October	55.7	42.0	69.0	7th	34.0	12th	30.0	28.0	27th	1.51	12	0.47	28th	52.0	54.0	54.0	3.05	69.4	48.2	101.3	3 3	29 890
November	47.0	37.0	54.0	19th	30.5	11th	34.0	28.0	12th, 26th	1.15	12	0.48	14th	44.0	47.0	43.3	1.3	89.0	40.0	53.6	1.8	29.970
December	42.7	28.6	47.0	23rd	23.5	6th	28.5	19.5	14th	0.30	5	0.10	25th	37.0	40.1	33.7	0.78	93 1	32.7	40.0	1.0	30.010

Total rain for year, 16.72 ins. No. of days precipitation, 127. Total bright sunshine for year, 1602.1 hours.

DIAGRAM SHOWING ARRANGEMENT OF EXPERIMENTAL PLOTS, 1933